December 1999
Vol. 23 No. 12

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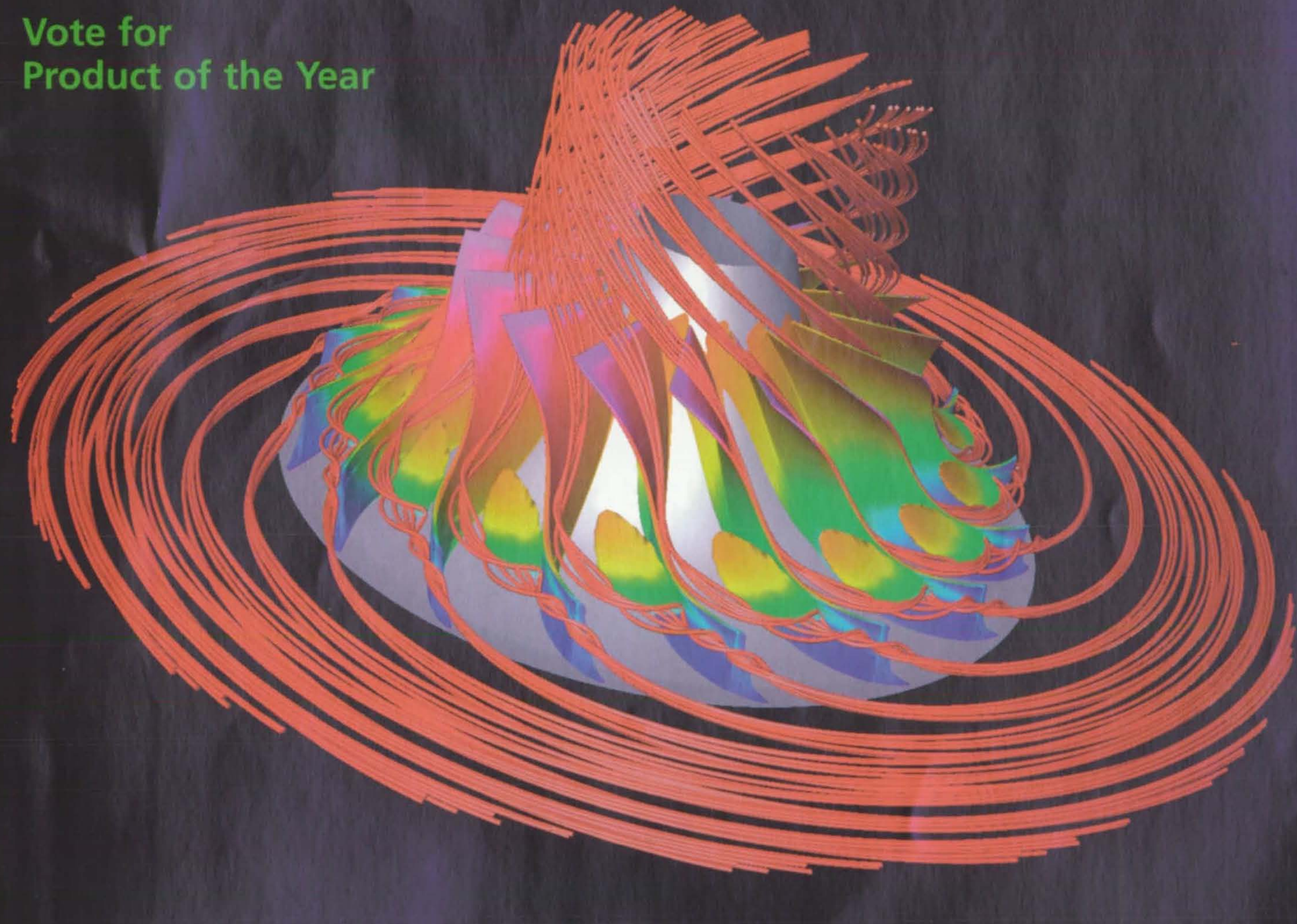

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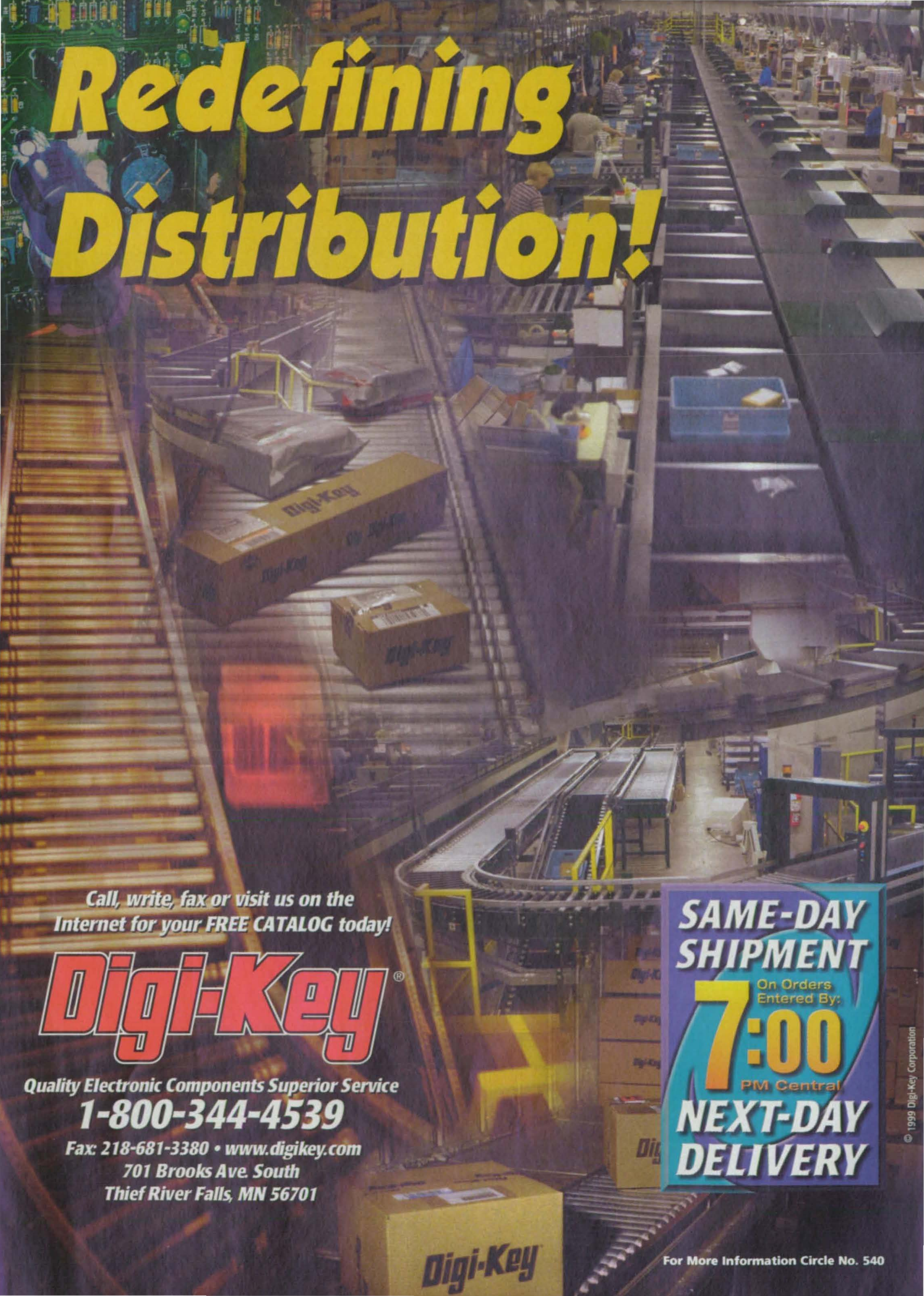
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NASA TECH BRIEFS
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DEPARTMENTS

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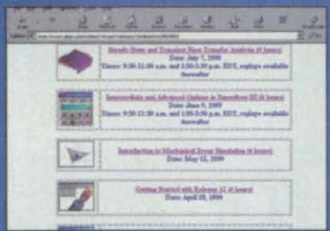

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The streaming video format used for all web broadcasts is designed for Microsoft Windows Media Player. Since most of Algor's customers operate on the Windows 95, 98, or NT platforms, using Microsoft tools such as Windows Media Player and Internet Explorer 4.0 or higher offers maximum compatibility, reliability and through-put. *The latest version of Windows Media Player can be downloaded at no charge from our web site or at www.microsoft.com.*

View Schedule of Upcoming Web Courses and Web Course Replays at:

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Email questions before or during a Web Course to: webcourse@algor.com. Or phone your questions directly to an engineer during the Web Course at: +1 (412) 967-2700 x3014.

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Contents *continued*

PRODUCT OF THE MONTH

Compaq Computer's new Deskpro AP240 workstations bridge the gap between high-end and entry-level workstations.

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ON THE COVER

In this impeller image, iso-surfaces of flow speed (based on the relative frame of reference) show blockage within the main channel — the iso-surfaces are colored by pressure. Streamlines, seeded on the blockage region, show recirculation patterns around the blocked passage. The simulation was created with FIELDVIEW 6 visualization software from Intelligent Light, Lyndhurst, NJ. For more information on the software, see New on Disk on page 62.

(Image simulation results courtesy of NREC)

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For More Information Circle No. 531

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For More Information Circle No. 533

Three spring-energizer designs make the Turcon® Variseal™ more versatile.

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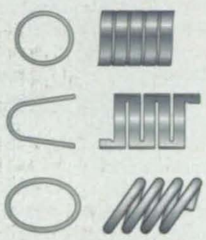

Helical

V-Spring

Slantcoil®

Choosing the right spring is a critical step in the design process. The Helical Spring applies the highest unit load, making it an excellent choice for static and slow-speed reciprocating applications. For high-speed reciprocating, or moderately fast rotary applications, the V-Spring is a better choice. This spring is also used for applications with abrasive environments where superior scraping is critical.

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For More Information Circle No. 532

NASA Commercial Technology Team

...industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
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(301) 286-5810
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Jet Propulsion Laboratory
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merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
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Kennedy Space Center
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Langley Research Center
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Dr. Joseph S. Heyman
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John H. Glenn Research Center at Lewis Field
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Marshall Space Flight Center
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sally.little@msfc.nasa.gov

Stennis Space Center
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technology@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

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NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

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rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

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Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

B. Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

Your July issue featured a Reader Forum letter from Mark Kane requesting information on purchasing a small sheet of tungsten for an enameling kiln. A good place to start may be with a company called Goodfellow in Berwyn, PA, which manufactures standard and precision-cut metal and steel sheets, rods, and tubes. They can be reached at 1-800-821-2870, or on the Web at www.goodfellow.com.

Arthur Lahey
RuMar Mfg. Corp.
Mayville, WI
414-387-2104

I have not been able to find radiation resistance data on Kevlar® fiber. I would appreciate any assistance.

Norm McFadden
norman_r_norm_mcfadden@rl.gov

*(**Editor's Note:** Norm, Kevlar® is a manmade organic fiber developed by DuPont®. Information on the fiber can be found on the DuPont website at www.dupont.com; or, you can contact DuPont's Corporate Information Center at info@dupont.com; phone: 1-800-441-7515.)*

I need to obtain information regarding an instrument to measure the yolk temperature of a chicken egg. Preferably, measurement would be done while the egg is traveling on a conveyor moving at about 25 fpm, and while it could be contained within a "pocket." I am looking for a non-contact sensor — one that would not require physically penetrating the shell. Output could be digital or analog, and could be a simple display, or sent to a PC or PLC. An alternative would be a sensor that would require removal of the egg manually. Thanks for any information you can provide.

Richard Koch
FPS Food Processing Systems
Lancaster, PA
rjkoch@fpsusa.com

Post your letters to Reader Forum on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and phone number or e-mail address.

PRODUCT OF THE MONTH

Compaq Computer Corp., Houston, TX, has introduced the Deskpro AP240 professional workstations, designed to serve as a bridge between the company's high-end Deskpro units and entry-level workstations. The desktop and mini-tower systems feature single Pentium III 600EB and 733-MHz processors in the Rambus-memory-based models, and single Pentium III 700-MHz processors in the SDRAM-memory-based models. The Rambus-based models also feature Intel's 820 chipset, maximum memory of 1 GB, 5 slots and 4 bays in the desktop model, 8 slots and 5 bays in the mini-tower model, 9-GB wide ultra2 SCSI standard drive, and a 40X CD-ROM. SDRAM models offer Intel's 440BX chipset, maximum memory of 768 MB, and a 32X CD-ROM. The systems offer 2D and entry-3D graphics.

For More Information Circle No. 744

New Device "Sees" Beneath Skin

NASA's Langley Research Center in Hampton, VA, has signed agreements with two medical centers to use NASA virtual reality technology to manage diseases. Studies will begin at the Strelitz Diabetes Research Institutes of the Eastern Virginia Medical School in Norfolk on patients with diabetes. Studies at the Behavioral Medicine Center at the University of Virginia Health Sciences Center in Charlottesville will follow patients with other circulatory disorders.

Artificial vision technology developed at Langley to help pilots train to fly in poor visibility can also aid diabetics at risk for nerve damage. The virtual reality device allows the patients to visualize and control the flow of blood to their arms and legs. Patients will use biofeedback to increase blood flow. The flow will be measured with sensors attached to the patients' fingertips. Skin-surface pulse and temperature measurements will be used to create a computer-generated image of what is happening to blood vessels under the skin.

Diabetes patients will wear a 3D virtual reality headset for a view of the contraction and expansion of their blood vessels. Researchers believe that by enabling the patients to visualize blood flow, it will help them learn to manage their disease better.

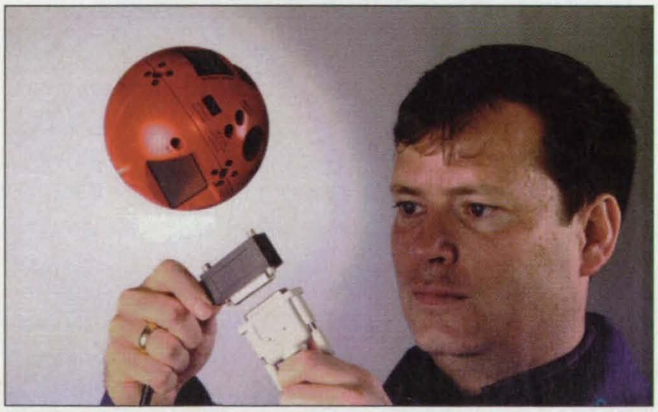
For more information, visit the project web site at http://tag-www.larc.nasa.gov/tag/index.html.

NASA's Intelligent Robot

Scientists at NASA's Ames Research Center in California are developing an autonomous robot to support future space missions. The size of a softball, the Personal Satellite Assistant (PSA) will be equipped with sensors to monitor environmental conditions in a spacecraft, including oxygen, carbon dioxide, and other gases; the amount of bacteria growth; and air temperature and pressure. The PSA also will have a camera for video conferencing, navigation sensors, wireless network connections, and its own propulsion components that will enable it to operate autonomously through the spacecraft.

The intelligent robot will serve as "another set of eyes, ears, and nose for the crew and ground support personnel," according to Yuri Gawdiak, the principal investigator for the project at Ames. The little round robot's compact design will allow it to operate in the tight spaces aboard the Space Shuttle's flight deck and in the International Space Station modules.

Besides data assistant capabilities, the PSA will also be able to remotely monitor payloads, especially when onboard crew members are not available. Another benefit is the ability to have several PSAs conduct collaborative troubleshooting activities. At least three PSAs would use formation flying to zero in on the location of a problem such as a pressure leak or temperature spike.



NASA Ames researcher Yuri Gawdiak displays the Personal Satellite Assistant (PSA), an autonomous intelligent robot designed to support astronauts on future space missions.

The long-term future goals of the PSA are to support remote diagnostic operations, and to substitute as necessary for damaged or nonfunctioning sensors on future spacecraft. "We hope to launch a Personal Satellite Assistant in about two years aboard a Space Shuttle, and in about three years aboard the International Space Station," said Gawdiak.

For more information, visit the project web site at http://ic.arc.nasa.gov/ic/psa, or contact NASA Ames at 650-604-3937.

Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Ground Isolation Circuit for Isolating a Transmission Line from Ground Interference

(U.S. Patent No. 5,841,467)

Inventor: Craig A. Davidson, Johnson Space Center

It is desirable to develop isolation circuitry for video systems and other wideband communication systems that could be more economically constructed and housed in smaller packages than is now the case. The circuit described herein uses a pair of balanced mixer circuits that respectively modulate and demodulate a baseband data signal with a high-frequency carrier signal of at least twice the frequency. The advantage of this approach is that the modulated signal can be isolated using RF transformers, which by comparison with video transformers are much less expensive and much smaller. The baseband signal is coupled to the low-frequency port of the mixer circuit, which modulates the baseband signal onto the carrier frequency supplied by a local oscillator, and provides the modulated signal to an RF transmission line. A second matched mixer circuit couples to the line to receive the modulated signal at its RF port. The same local oscillator couples to a port on the second mixer circuit. The oscillator signal, which is the carrier signal, cancels the latter, leaving the baseband signal.

Controlled Thermal Expansion Coat for Thermal Barrier Coatings

(U.S. Patent No. 5,863,668)

Inventors: William J. Brindley, Robert A. Miller, and Beverly J. M. Aikin, Glenn Research Center

The disadvantages of thick graded thermal barrier coatings in some applications are twofold. Added coating weight is clearly a penalty for applications in the rotating parts in gas turbines, especially aircraft turbines. Furthermore, thick thermal barriers in high-temperature applications require the outer insulating layer to be thick enough to insulate the graded areas, but again the coating becomes too thick and heavy. The present invention provides enhanced thermal fatigue life through modification of the bond coat's coefficient of thermal expansion in targeted regions of the coat's microstructure. The coating comprises a first bond-coat layer of MCrAlX, in which M is a material selected from a group consisting of nickel, cobalt, and iron and X is selected from a group of reactive elements such as yttrium, zirconium, hafnium, and ytterbium. A second bond-coat layer comprises a MCrAlX matrix in which particles of a particulate are dispersed throughout, and is applied to the first coat. In the second, M is a material selected from nickel, cobalt, iron, and mixtures thereof, and X is again selected from reactive elements.

Integral Ring Carbon-Carbon Piston

(U.S. Patent No. 5,884,550)

Inventor: G. Burton Northam, Langley Research Center

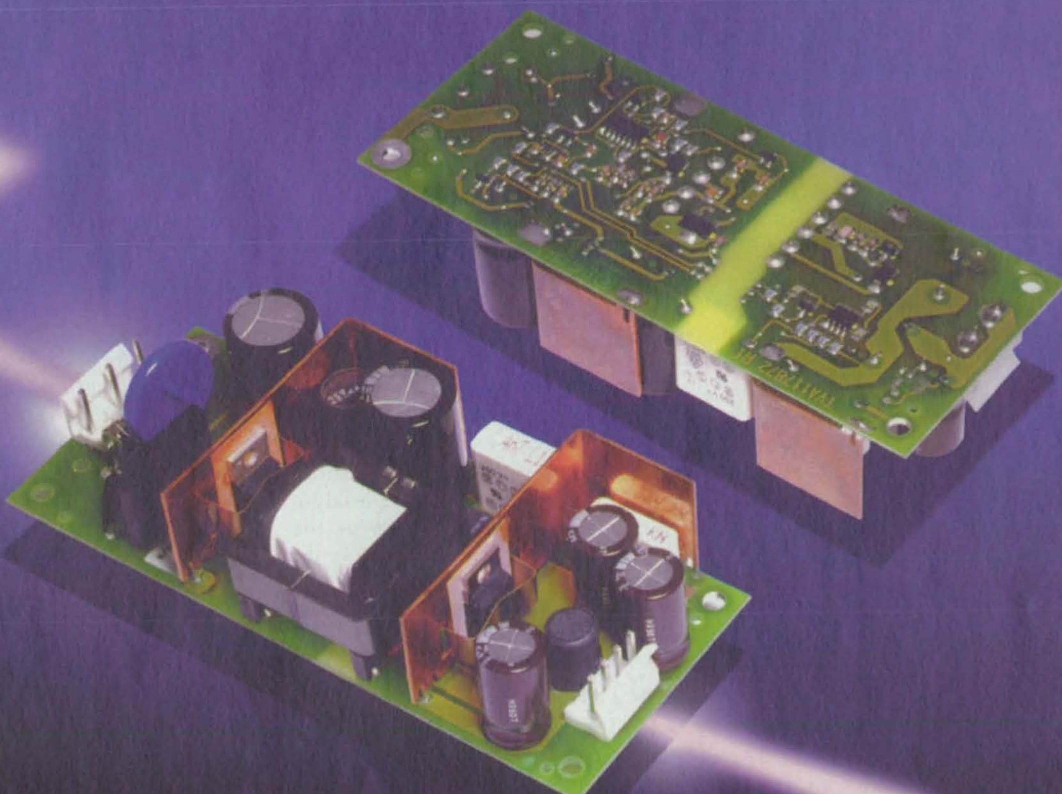
In many applications, including engines, aluminum alloy pistons have replaced steel and cast-iron pistons because they are lighter. But aluminum alloys used in high-speed airplane engines and lightweight diesel engines frequently fail due to severe thermal loads at elevated operating temperatures above 600 °F. Also, conventional pistons fabricated from steel or aluminum alloy have relatively high coefficients of thermal expansion, requiring a small clearance gap between the piston and the cylinder liner. Conventional pistons employ piston rings to seal the gap against "blow-by" of compression gases. The invention involves the use of carbon-carbon composites, a predominantly carbon matrix material reinforced with predominantly carbon fibers. Carbon-carbon composites are inherently lightweight, maintain their strength at temperatures up to 1500 °F, and can be manufactured with low coefficients of thermal expansion, low specific heat, and tailorable thermal conductivity. Thus the invention's integral ring piston — a reciprocating piston manufactured with a cantilevered seal in its crown and/or skirt, fabricated from carbon-carbon composite materials — is an improvement.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 10 for a list of office contacts.

December 1999

etb

ELECTRONICS TECH BRIEFS



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The Quasielastic Neutron Spectrometer at Argonne National Laboratory in Argonne, IL, is used to observe the way in which neutrons are scattered by atoms, so that materials research scientists can study the characteristic motion of materials on the atomic level. This gives microscopic-level information on the mechanics of diffusion, the motion of magnetic spins, and atomic vibrational and rotational motion. Such analysis helps scientists learn more about the inner workings of materials and provides data not possible with any other analytical method.

One example is in the area of catalysts, which are in common use by the chemical industry. Catalysts are used to speed up and selectively favor the production of particular chemicals such as gasoline and the organic feedstock for a wide variety of chemical processes, which are subsequently used to make materials such as polymers. With the QENS spectrometer it is possible to probe the effect of the catalysts on parameters such as the rate at which the reactants and products move around in the catalysts. Such fundamental measurements aid in the design of more efficient materials.

Another example is the rate at which molecules move through clays, which have slit-like cavities that can adsorb water and, for instance, organic contaminants. Again, neutron scattering on QENS can be used to characterize the role of the clay surface and the effect of remediation processes on the fundamental motion of the contaminants, potentially leading to improved environmental remediation techniques.

Many very unusual designs are done at Argonne. As Henry Belch, a design engineer there, put it, "What we build you would not normally see anywhere else in the world." Because the QENS instrument uses toroidal-shaped crystal analyzer arrays to direct the path of neutron beams, "we get some very complicated shapes," according to Belch. These shapes would be virtually impossible to design and draw without the aid of 3D modeling and analysis software. Although the design of the QENS is quite complex, Belch says they were able to build it in less than one year thanks to Mechanical Desktop® from Autodesk.

From 2D to 3D

Belch serves as the chief design engineer for the Intense Pulsed Neutron Source Division at Argonne. He came to Argonne from General Dynamics, where he designed submarines using 3D modeling techniques. "When I first came here four years ago, engineers were using 2D drawings and sketches," Belch said. "I began using Mechanical Desktop after seeing it at a trade show. It had everything we needed."

In addition to some very complex shapes, the QENS instrument has some very complicated guide tubes and beams. It requires internal shielding to protect personnel from neutrons. It has 22 analyzer arms, each of which includes a crystal analyzer array, a beryllium filter, and a detector bank. Neutrons scatter off the sample, then strike the analyzer arrays, which are composed of highly oriented pyrolytic graphite. Neutrons that meet the diffraction criteria of the graphite are redirected and focused toward the detector bank, thus "analyzing" them for particular wavelengths. Another way of understanding the role of the analyzers is to consider them as mirrors that reflect the neutrons from the sample into the detectors. These graphite mirrors only reflect neutrons with specific speeds (diffraction), similar to an optical mirror that only reflects one color of light.

As Belch explained it, "To create neutrons, we direct a proton beam into a depleted uranium target. As the proton beam hits the target, large quantities of neutrons are given off, which are 'cooled' or slowed down by making them go through a container of cold solid methane at about 20 K—minus 253 degrees Centigrade." These neutrons are then allowed to travel down to the material that is being studied. They reflect off atoms in the sample and—because they have no charge—go through the electron shell and collide with the nuclei of the atoms. "Since neutrons scatter in various directions based on the structure of the sample," Belch said, "we get unique information that can be used to better understand these materials and their properties."

Belch designed the toroidal-shaped crystal arrays on QENS using Mechanical Desktop. "If you take an array and focus it onto a point, you get some very strangely shaped reflected neutron beam paths. I used both the advanced surfacing and solids modeling capabilities of Mechanical Desktop to design the paths and generate shielding, parts, and components."

Belch reported that some people said the design was too aggressive. They said the entire concept was too complicated

and would be impossible to fabricate. "I used Mechanical Desktop's interference analysis and visualization capabilities to demonstrate the concept. We could see the results before we built the instrument, and we proved that it could work."

During the course of the project, Belch says he used every feature available in Mechanical Desktop.

Inside the Software

Mechanical Desktop software runs on a Windows 95/96/NT computer platform and combines several important features:

- Full drafting capabilities of AutoCAD, with built-in support for ANSI, ISO, DIN, and JIS specs. It can produce drawings such as aligned, orthographic, isometric, and various section views.
- NURBS modeling for creating and editing surfaces, including wireframes.
- Assembly modeling that can create large assemblies containing hundreds of parts, edit parts in top-down or bottom-up modes, and create mechanism-like assemblies.
- Interference analysis for parts, subassemblies, or the entire assembly.
- Solid renderings in full color, including photorealistic drawings.
- Compatibility with industry data-exchange formats, such as IGES, STL, SAT, and BMP.

"I used Mechanical Desktop to design the base instrument," Belch said. "Since then we've gone from three crystal arrays to 22 arrays."

Belch said the software is easy to learn. "When we first started using Mechanical Desktop, our engineers and draftsmen were using an old version of AutoCAD with someone's specially developed menus. They weren't doing any 3D modeling at all. Fortunately, it didn't take long to learn Mechanical Desktop, and now everyone is working in 3D. We have several licenses, including systems on a network, and the software is being used full time."

Fine Tuning the Design

After proving the basic design concept, Belch began testing and refining. "We used Mechanical Desktop's assembly modeling capabilities to assign materials to various parts of the instrument and perform an analysis of the entire assembly. We used a wide variety of materials, including cadmium, aluminum, several kinds of polymers, and pyrolitic graphite crystals. We also did nonlinear stress analysis using NASTRAN, a high-end finite element analysis application from Autodesk MAI partner MSC Software."

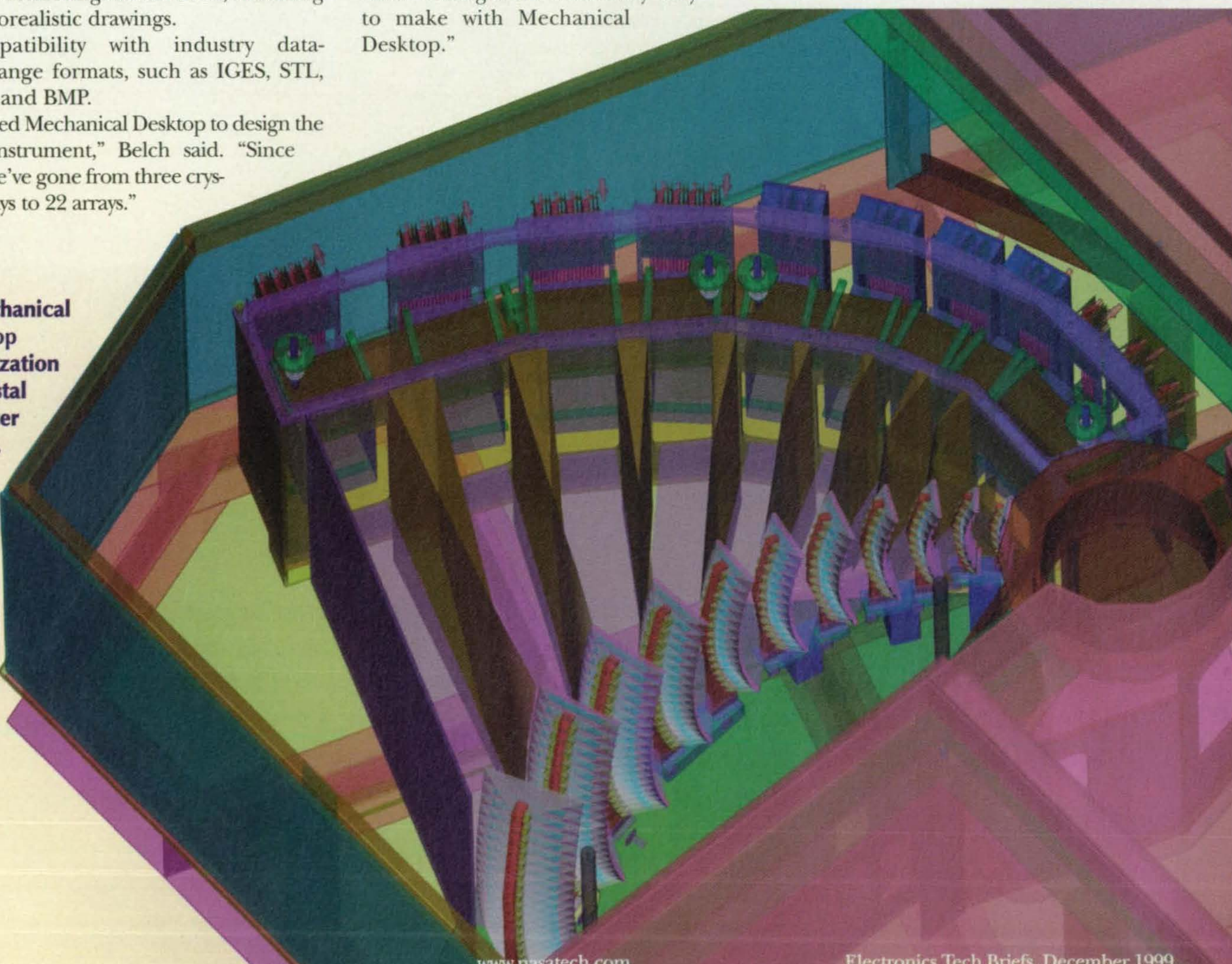
Changes were easy to handle. "If a change had to be made, the software updated everything automatically, including drawings and models," Belch said. "Changes are extremely easy to make with Mechanical Desktop."

The instrument includes a large tank and weighs 3800 pounds. "We did a very detailed weight and center-of-gravity analysis on the final version of the instrument, and I was very pleased to see that the center of gravity was right on and the actual weight turned out to be within 40 pounds of the calculated weight." For a 3800-lb. system, that is an error of just one percent.

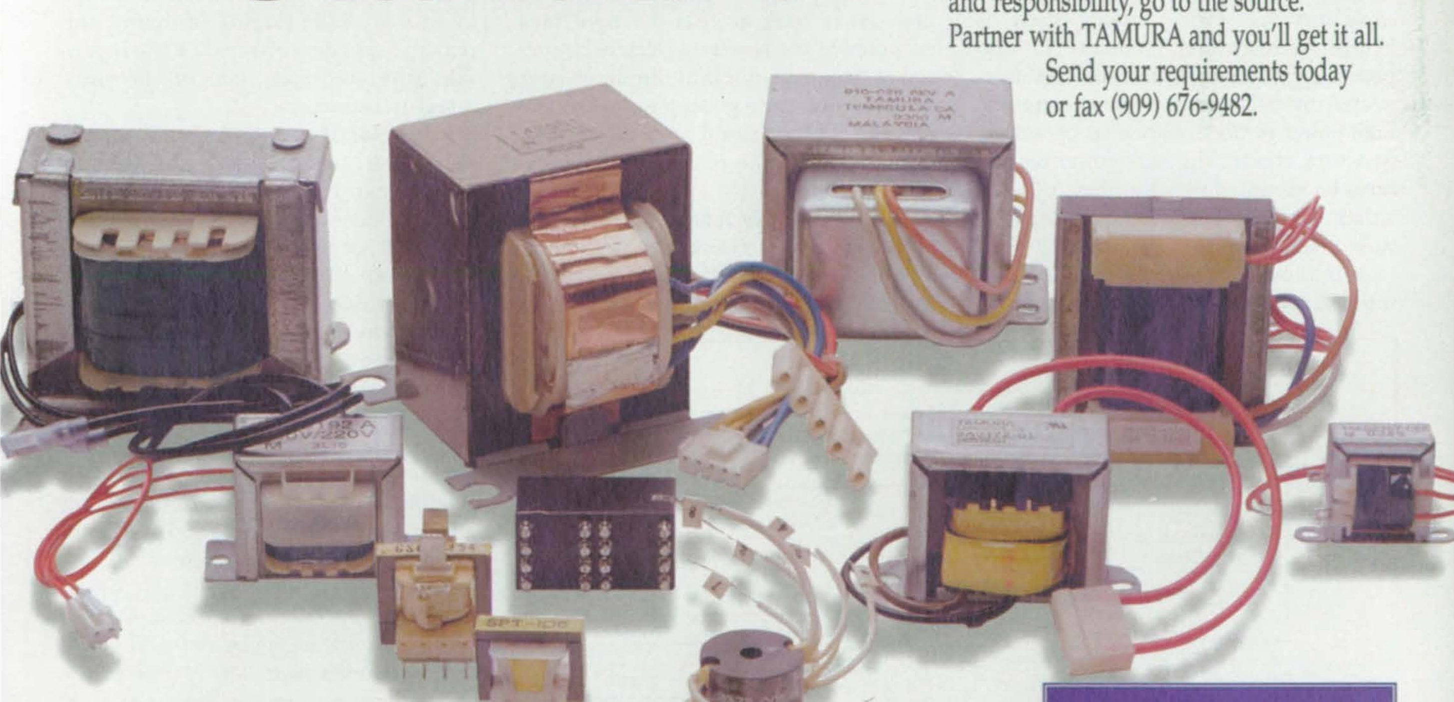
"When the tank and instrument were installed, it went like clockwork," Belch said. "It could not have gone better."

In all, Mechanical Desktop produced about 250 drawings and helped Belch greatly in taking the instrument from design concept to finished product. For his efforts, Belch won a Pacesetter Award, a significant award given by Argonne in recognition of exceptional achievement.

For more information, contact Henry Belch at Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439-4814; (630) 252-6061; fax: (630) 252-4163; e-mail: hbelch@anl.gov. The QENS instrument was designed and is in use at the Intense Pulsed Neutron Source at Argonne. This facility is funded by the U.S. Department of Energy, BES-Materials Science, under contract W-31-109-Eng-38.



A Mechanical Desktop visualization of crystal analyzer arrays.



High-Power-Density DC-to-DC Power-Converter Modules

Major features include multilayer hybrid packaging and a transformer-coupling feedforward/feedback control scheme.

John H. Glenn Research Center, Cleveland, Ohio

Dc-to-dc power-converter modules that operate with input potentials from 60 to 140 V and generate various output potentials up to 15 V are undergoing development. Designed specifically for use aboard planned spacecraft wherein electric power will be supplied at bus potentials from 70 to 120 V, these power-converter modules could also be useful in a variety of terrestrial applications. The fully developed versions of these power-converter modules are expected to operate at power densities about 33 percent greater than those of currently available commercial 28-V-input power-converter modules.

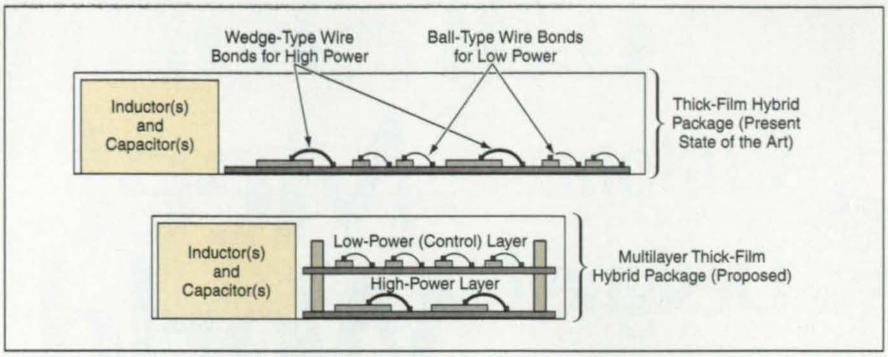


Figure 1. The **Multilayer Thick-Film Hybrid** approach makes it possible to use package volume more efficiently than does the state-of-the-art single-layer thick-film hybrid approach.

The increase in power density will be achieved by use of multilayer thick-film hybrid packaging conceived expressly for this purpose. This can be explained by reference to Figure 1, which depicts a typical state-of-the-art power converter of single-layer thick-film hybrid design and a proposed electrically equivalent power converter of a two-layer thick-film hybrid design. In addition to large inductors and capacitors for storing energy, there is hybrid circuitry that includes (1) low-power signal-level control devices connected by ball-type wire bonds and (2) high-power devices connected by wedge-type wire bonds. The high-power devices must be mounted with low thermal resistances between themselves and a heat sink; therefore, the high-power devices must be mounted on a substrate in contact with the floor of the converter housing.

The heat-sinking requirement for the low-power devices is less stringent, making it possible to mount these devices on a substrate not in direct contact with the heat sink. Taking advantage of this possibility in the proposed two-layer design, the low-power devices would be placed on a separate substrate. The high-power layer would still be mounted in contact with the heat sink, but the low-power-device layer would be mounted above the high-power layer, so that the floor area occupied by the power-converter circuitry would be less than it is in the single-layer design. Thus, for a given power throughput, the package could be made smaller; in other words, the power density could be larger.

Another notable feature of the developmental power converters is a transformer-coupled feedforward/feedback control scheme (see Figure 2). Heretofore, it has been common practice to implement power-converter control circuitry with optocouplers for electrical isolation between input and output sides. However, optocouplers lack the long-term reliability required for the intended spacecraft application. In the developmental control scheme, pulse-width-modulation (PWM) control of the power supplied to the primary winding of a main power transformer is effected on the input side, while sensing of output current and voltage is effected on the output side (the secondary side of the main power transformer).

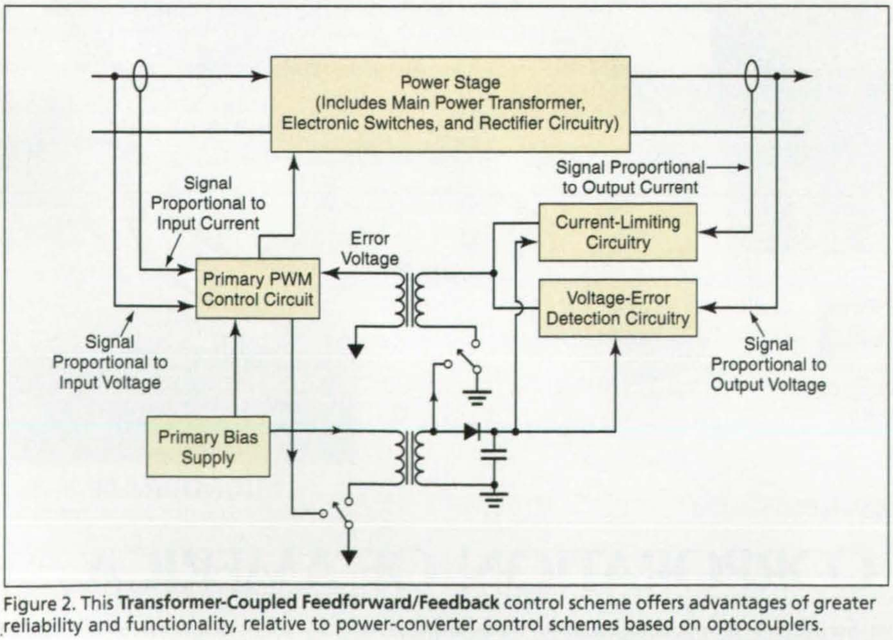


Figure 2. This **Transformer-Coupled Feedforward/Feedback** control scheme offers advantages of greater reliability and functionality, relative to power-converter control schemes based on optocouplers.

Power for the secondary-side control circuitry is provided from the primary side through a pulse transformer (distinct from the main power transformer) excited at the switching frequency. An error signal from the control circuitry on the secondary side is fed back to the control circuitry on the primary side via another pulse transformer. This transformer-coupled feedforward/feedback scheme makes it possible to turn on the secondary-side control circuitry before turning on the main power, thereby making it possible to exert control over the output during startup and during recovery from transient short-circuit conditions.

This work was done by Ming Chen of VPT, Inc., for **Glenn Research Center.** *For further information regarding VPT and their standard product line of high-density dc/dc converters, you can contact them at (540) 552-5000 or visit their website at www.vpt-inc.com.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135.

Refer to LEW-16883.

Acousto-Optic Tunable Filter Spectrometers

etb TEST & MEASUREMENT

Spectroscopic instruments using AOTFs have several advantages over conventional grating-based instruments.

Army Research Laboratory, Adelphi, Maryland

Spectrometers are used for applications such as chemical analysis, remote sensing, environmental measuring, and optical measurements. Most spectrometers utilize prisms and gratings, where the dispersion of light depends upon the angle and rotation of the grating. But gratings and other moving parts are undesirable in spectrometers because they cause unwanted vibrations, they can go out of alignment, and they are difficult to maintain. In addition, the spectral range and resolution of traditional spectrometers are limited.

To combat these disadvantages, electronically tunable optical filters with no moving parts were developed using novel acousto-optic (AO) technology. These acousto-optic tunable filters (AOTF) are being utilized in the design of new spectroscopic instruments as replacements for conventional grating-technology-based optical instruments.

Acousto-optics involves the interaction of sound and light in dielectric material. When sound propagates through a solid or liquid, compressions are created in the material that cause variable refraction of the passing light, pulling color features from it. Acousto-optic tunable filters are solid-state electronically tunable optical filters that select precise wavelengths by applying the appropriate RF frequency. Filters can be used to pass light with either a single wavelength or multiple wavelengths, depending on the RF signal applied. A high-frequency electrical signal is converted into an ultrasonic wave by a piezoelectric oscillator (transducer) bonded to an AO medium. Sound waves travel through the medium and diffract light. Compared to traditional filters, AOTFs offer fast and agile tunability, and narrow spectral bandwidth selection.

Utilizing AOTF technology, scientists at the Army Research Laboratory (ARL) developed acousto-optic-based portable spectrometers for remote sensing of chemical and biological agents. The spectrometers do not have moving parts, are vibration-insensitive with high-frequency selection sensitivity, and will allow the user to select a range of colors in the visible and near-IR spectral regions. The spectrometers have resolution high enough to perform real-time analytical chemical measurements in the field or on a moving platform.

ARL's spectrometers are compact and robust, making them useful for work in the field, as well as in the laboratory. The inventors also developed a spectroscopic accessory that allows for more efficient collection of light, when only a fraction of light can be collected with traditional systems. ARL's spectrometers can be used to carry out both fluorescence and Raman spectrosopic measurements with only minor adjustments to the system, which was previously impossible using only a single system. Whereas highly trained specialists are needed to run experiments with traditional spectrometers, ARL's devices can be operated by nonspecialists.

The AOTF-based spectrometers at ARL can be used for spaceborne environmental monitoring, detection of forest fires, underwater monitoring of gases, water quality monitoring, monitoring of contaminants in the ground, the detection of cancer, drug interdiction, and airport security. They may also be used to perform real-time process control and quality assurance in pharmaceutical manufacturing, paper manufacturing, food processing, and optics and semiconductor manufacturing.

This work was done at the **Army Research Laboratory**. *For more information, please contact Ms. Norma Cammarata, ARL's Technology Transfer Officer, at 2800 Powder Mill Rd., AMSRL-CS-TT, Adelphi, MD 20783-1197; (301) 394-2952; fax: (301) 394-5818; e-mail: normac@arl.mil.*

Array Detector for Charge-Detection Mass Spectrometer

SENSORS

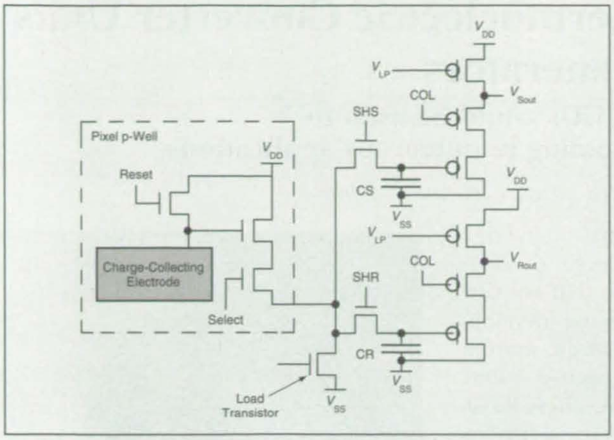
Multiple smaller electrodes perform better than does a single larger electrode.

NASA's Jet Propulsion Laboratory, Pasadena, California

The pixelated array detector (PAD) is a planar array of complementary metal oxide/semiconductor (CMOS) charge-collecting electrodes and readout circuitry for measuring the electric charges on particles in a charge-detection mass spectrometer (CDMS). In comparison with a single-Faraday-cup detector occupying the same total area, the PAD offers advantages, as explained below.

The CDMS approach offers a faster, cheaper alternative to pulsed gel electrophoresis and other techniques for measuring the masses of a variety of large molecules (masses > 10^6 daltons) and similarly sized particles. Examples of particles amenable to CDMS analysis include polymer molecules, bacteria, viruses, and airborne contaminant particles. Whereas a typical analysis by pulsed gel electrophoresis takes days, a typical analysis by CDMS takes minutes.

In a CDMS, a particle to be analyzed is first subjected to electrospray ionization, causing it to bear an electric charge as high as hundreds of thousands of fundamental (electron) units. The particle is then accelerated electrostatically into a Faraday tube connected to circuitry for measuring the time of flight of the particle along the tube. Upon leaving the Faraday tube, the particle impinges on a charge-collecting electrode or else enters a Faraday cup, the electrode or cup being connected to a charge-sensitive amplifier. The time of flight through the Faraday tube is related in a known way to the charge-to-mass ratio of the particle. Thus, the mass of the particle can be calculated from the Faraday-tube time-of-flight measurement and the measurement of collected charge.



One Pixel Circuit and part of the circuit common to all pixels in a column is depicted in this abbreviated schematic diagram.

The collection area and thus the fraction of ions collected increases with the size of the charge-collecting electrode, but the capacitance and associated electronic noise also increase with size. This leads to the basic idea of the PAD, which is to use a sufficiently large total charge-collection area to obtain the desired charge-collection efficiency while apportioning the area among multiple small electrodes or Faraday cups for measurement of the charge deposited into them. Because each electrode occupies a small fraction of the total charge-collection area, the capacitance and electronic noise are reduced accordingly.

A proposed CDMS containing a PAD would include an optional electrostatic deflector, which, when triggered by the passage of an ion through the tubes, would prevent additional ions from reaching the PAD until the PAD had been read out and reset. The ion-passage-induced trigger signal would also be used to gate the readout of the pad to reduce the noise associated with collection of dark current. The time needed to clock the flight of a single ion and measure its charge should be no longer than a few milliseconds; thus, it should be possible to measure a hundred or more ion masses per second and to accumulate a complete mass spectrum with data on thousands of ions in less than 30 seconds.

A prototype PAD contains a 28-by-28 array of pixels with a 40-by-40-μm pitch. The charge-collection electrode of each pixel is a 36-by-36-μm metal patch on its surface. Each pixel (see figure) contains a source-follower input transistor, a row-selection transistor, and a row-reset transistor. At the bottom of each column of pixels there is (a) a load transistor, (b) an output branch containing a sampling switch (SHS) and sample-and-hold capacitor (CS) for storing signal levels, and (c) a similar output branch with a switch (SHR) and sample-and-hold capacitor (CR) for storing reset signals. There are also source followers with a column-selection switches (COL) at both ends of each column. The reset and signal levels are read out differentially, suppressing fixed pattern noise. If signal levels are read out twice — once before and once after integrating charge — then *kTC* noise (where *k* is Boltzmann's constant, *T* is absolute temperature, and *C* is capacitance) is also suppressed. In tests, the prototype PAD exhibited a noise floor of 90 electrons root mean square at room temperature.

This work was done by Stephen D. Fuerstenau and George A. Soli of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components category.*
NPO-20128

Improved Thermoelectric Converter Units and Power Generators

etb COMPONENTS

Rugged, compact TCUs could be used to provide power or cooling in numerous applications.

John H. Glenn Research Center, Cleveland, Ohio

Improved thermoelectric converter units (TCUs) and radioisotope thermoelectric generators (RTGs) that contain them have been undergoing development for use as small, lightweight sources of electricity at potentials up to 5 V and power at levels up to 40 mW. These RTGs are intended primarily for supplying power to operate electronic equipment in outer space or at remote or uninhabitable locations on Earth; terrestrial applications could include monitoring of nuclear-waste-storage facilities, meteorological monitoring at polar locations, deep sea exploration, and monitoring of geological activity inside volcanic craters and at underground locations.

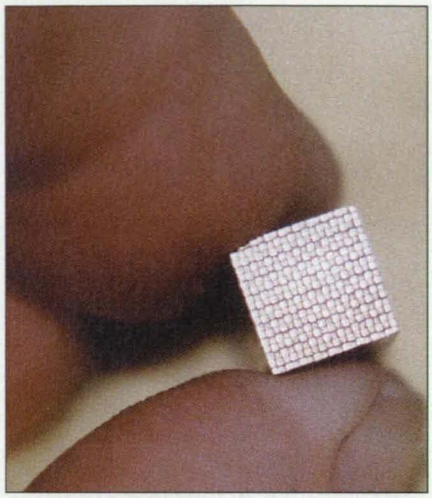


Figure 1. A **TCU Is a Rectangular Parallelepiped Module** containing p- and n-doped pieces of bismuth telluride in a square array. The cold side is shown here. The overall dimensions of the module are 0.291 by 0.291 by 0.9 in. (7.4 by 7.4 by 22.9 mm).

In general, a thermoelectric generator includes a TCU plus a source of heat. In the case of an RTG, the source of heat is a radioisotope heater unit (RHU). The present RTG design is derived partly from the design of 75-mW radioisotope power systems that were built for the United States government in the late 1970s and early 1980s. The present design also incorporates some of the concepts reported in "Miniature Radioisotope Power Source" (NPO-19339), *NASA Tech Briefs*, Vol. 19, No. 9 (September 1995), page 60. The RHU in the present design generates thermal power of 1 W and is of a type that has been proven in use aboard spacecraft to warm instruments that are sensitive to cold.

Alternatively, the improved TCUs could be energized by nonradioactive heat sources, including sources of waste heat (e.g., household appliances, power tools, camping equipment), small burners (similar to cigarette lighters) that burn hydrocarbon fuels, or any of a variety of other sources that are inexpensive and readily available. Power supplies based on this concept could be used to charge batteries or to operate low-power electronic equipment under emergency or outdoor conditions, for example. These power supplies offer an important additional advantage in that they could function over wide temperature ranges, including temperatures both above and below the operational temperature ranges of chemical batteries. The improved TCUs could also be used as heat pumps or coolers, especially in electronic equipment; in comparison with conventional thermoelectric coolers, these TCUs would be more durable and could be made smaller.

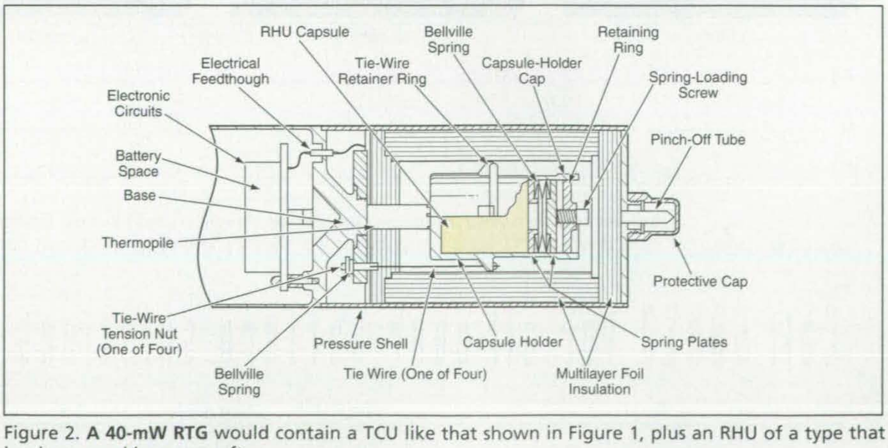


Figure 2. **A 40-mW RTG** would contain a TCU like that shown in Figure 1, plus an RHU of a type that has been used in spacecraft.

A TCU is a thermopile made from state-of-the-art thermoelectric materials — in this case, p- and n-doped, vacuum-hot-pressed bismuth telluride. The present developmental TCU is fabricated as a module (see Figure 1) that contains an 18-by-18 square array of alternating p- and n-doped pieces of bismuth telluride separated by pieces of polyimide film. Each element of the array is a square 0.015 in. (0.38 mm) wide. The overall dimensions of the module are 0.291 by 0.291 by 0.9 in. (7.4 by 7.4 by 22.9 mm). The elements of the array are electrically connected in series by gold contact strips on the hot and cold sides. The design hot and cold junction temperatures are 250 and 25 °C, respectively.

Fabrication of the module involves a process of stacking, cutting, and restacking pieces of the p- and n-doped thermoelectric material and polyimide films, followed by placing the final stack in alignment tooling and vacuum hot pressing the final stack to bond the pieces together. Accurate alignment and proper bonding of the array elements in the stack are prerequisite for the next step, in which the gold contact strips are applied by a photo-masking/deposition process used commonly in the electronics industry.

Figure 2 is a simplified cross section of a proposed RTG that would incorporate the developmental TCU. The RHU capsule would be contained in an aluminum capsule holder, which would be mounted in contact with the TCU and pressed against the TCU by tension in four spring-loaded titanium tie wires. The RHU capsule would be spring-loaded to keep it stationary within the holder in the presence of shock and vibration and to minimize thermal resistance between the RHU and the TCU. A thermally conductive electric insulator (made of boron nitride) would be placed between the capsule holder and the hot side of the TCU to prevent electrical short-circuiting of the TCU. Thermal insulation for the hot parts of the RTG would comprise multiple layers of aluminized polyimide film interspersed with layers of ceramic paper. The interior of the RTG could be either evacuated or else filled with xenon.

This work was done by John C. Bass of Hi-Z Technology, Inc., and Alex Borshchevsky of NASA's Jet Propulsion Laboratory for **Glenn Research Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135.

Refer to LEW-16556.

For More Information Circle No. 463

NEW PRODUCTS

PRODUCT OF THE MONTH

Microcircuit Board Plotter

LPKF Laser and Electronics, Beaverton, OR, has released the ProtoMat® C60 printed circuit board prototyping system. The company says the C60 allows the production of high-precision microfine prototype PCBs in the electronic workshop without chemical etching. The ProtoMat C60 features a variable high-speed milling/drilling spindle with speeds between 5,000-60,000 rpm. LPKF says the cast construction of its baseplate guarantees high repeat accuracy (high resistance against torsion). According to LPKF, fine pitch circuits of only 100 µm isolation width can be produced using micro milling tools, and the smallest possible diameter for drilling is 8 mils.

For More Information Circle No. 751

AC/DC Input Power Supply

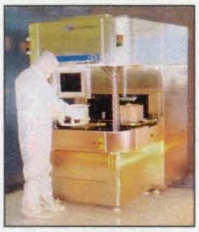
Ericsson Components, Energy Systems, Richardson, TX, offers the PLX 5516, a 50-W AC/DC universal input power supply designed as a low-cost front end to distributed power applications in communications, networking, computer, and telecom equipment. Available with either 24-V or 48-V output, it uses proprietary enhanced flyback topology that Ericsson says contributes to the exceptional mean time between failures of more than 300 years. The open frame design has a footprint of 55 × 133 mm, achieving power density for free convection cooling of 3.6 W per cubic inch.

For More Information Circle No. 752

Production Safety Analyzer

QuadTech, Marlborough, MA, has added the Guardian 6100 production safety analyzer to its line of electrical safety test instruments. Designed for fast and easy production testing of medical electronic products, according to the company, it is the first safety analyzer able to perform five essential electrical safety tests in one unit. The instrument can perform AC hipot tests from 50-5,000 V, DC hipot tests from 50-6,000 V, insulation resistance measurements over the range of 100 kΩ to 50 GΩ, ground bond testing to 30 A, and line/earth leakage measurements from 0.1 µA to 9.999 mA.

For More Information Circle No. 753



Nanotopology Analysis System

The NanoMapper metrology tool from ADE Phase Shift, Tucson, AZ, is a high-precision device for wafer, semiconductor equipment, and semiconductor device process development facilities. Based on the Semiconductor Industry Association National Technology Roadmap for Semiconductors, which defines rules to enable cooperative development of technologies required to maintain Moore's Law, NanoMapper responds with design rules down to 0.1 micron. NanoMapper provides whole-wafer topology data for 200-mm and 300-mm wafers.

For More Information Circle No. 754

SMD Test Clip Family

Pomona Electronics, Pomona, CA, designed its new Micro SMD Grabber® test clip family for use in R&D labs for prototype design and debugging of fine-pitch IC packages. Three styles are offered, including short- and long-tip styles for 0.8-mm to 0.5-mm lead pitches and one for lead pitches as small as 0.3 mm. Pomona says the grabbers can be used with virtually any fine-pitch IC, including QFP, PQFP, SSOP, and TSOP and TSSOP packages. The company says that the Micro SMD Grabber's thin body design allows for side-by-side stacking for adjacent lead probing. All styles can be used at frequencies up to 100 MHz and are supplied with flying leads for logic-analyzer attachment.

For More Information Circle No. 755

Low-Voltage Power MOSFETs

The new OMNIFET II family of fully autoprotected low-voltage power MOSFETs from STMicroelectronics, Lexington, MA, achieves lower conduction losses through reduced on-resistance, small structural volume, and a high level of ruggedness and avalanche energy handling capability, according to the company. The VIPower MO-3 technology allows a rugged power MOSFET to be combined with on-chip analog and digital circuitry. The new family has integrated user-transparent clamping and protection circuits, including linear current limiting, and overvoltage clamp circuitry.

For More Information Circle No. 756

Ultrathin Ferrite RFI Suppressors

FerriShield Inc., New York, NY, offers a low-profile ferrite product group that includes very thin styles, minimizing space and weight requirements in electronic equipment. Six sizes accommodate flat cables up to 40-conductors and widths up to 2.00 in. (50.8 mm) with impedances between 109 and 245 Ω(at 100 MHz) for suppression of interference up to 1 GHz while allowing data signals to pass unimpeded. A series with shock-mount adhesive foam bases are suitable for thin flex circuits and SCSI 2 flat cables on 0.025-in. (0.64-mm) centers.

For More Information Circle No. 757

Flip-Chip Bonding System

AnoTech Corp., Hauppauge, NY, says that its FCB-5500 flip-chip bonding system provides reel-to-reel loading of flexible substrates and pulse-heated thermal compression bonding for Au-Au, Au-Sn, and eutectic interconnections. The company says the FCB-5500 achieves 12-micron placement accuracy at 3 sigma levels, and its substrate handling system automatically indexes flexible substrates up to 150 mm in width. Real-time force feedback provides programmable control from 30 grams up to 10 kilograms.

For More Information Circle No. 758

Open-Loop Current Sensor

F. W. Bell, Orlando, FL, a division of Bell Technologies, a Sypris Solutions company, introduces the RS/RSS series open-loop current sensor family. Bell says that the RS/RSS series accurately measures AC and DC currents and provides electrical isolation between the circuit being measured and the output of the sensor. One package provides nominal current ranging from 100 to 1000 A and can be panel- or bulkhead-mounted. The series consists of 14 models supporting current-sensing applications ranging from 100 to 1000 A AC/DC with a frequency range from DC to 25 kHz.

For More Information Circle No. 759

Digital Couplers for Surface Mount

The 8-channel isolated digital couplers, the ISO508 (unidirectional) and ISO518 (bidirectional), from Burr-Brown Corp., Tucson, AZ, are newly available in surface-mount packages. These couplers are based on the company's capacitive barrier technology, which Burr-Brown says has several advantages over optical coupling: lower power consumption (in a 16-channel bus, up to 70 percent), reduction in PCB area (up to 80 percent), and lower overall system cost. They have 1500-V rms isolation and input and output buffers, allowing multiple access to a data bus.

For More Information Circle No. 760

Temperature-Compensated Crystal Oscillator

Fox Electronics, Ft. Myers, FL, introduces the 312BE temperature-compensated crystal oscillator (TCXO), designed for portable, telecom, data, and test equipment applications. Measuring 7 × 5 × 2 mm, it has a ceramic base and a metal cover, making it suitable for surface-mount applications. Frequency range is 12,600-19,800 MHz. Frequency tolerance at 25 °C is -0.5 to +0.5 ppm, and frequency stability is -2.5 to +2.5 ppm over the operating temperature range, which is -20 °C to +75 °C. Output waveform is a clipped sine wave with a minimum peak-to-peak level of 0.8 V, and input current is 2.0 mA max.

For More Information Circle No. 761

Vol. 23, No. 12 December 1999 This form expires: May 31, 2000

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1a. Are you involved in advising, recommending, specifying, or approving the purchase of computer-aided design (CAD) software for your company? ☐ Yes ☐ No

1b. If yes, do you plan to increase your purchase of CAD software in the next 12 months? ☐ Yes ☐ No

2. Which of the following types of CAD software do you now use? (check one) ☐ 2D ☐ 3D ☐ Both

3. Please list the names of CAD packages you (or your department) currently use.

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4. Please list any additional CAD packages you are considering purchasing in the next 12 months.

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Launch Control Systems Upgraded With Real-Time Graphics Software

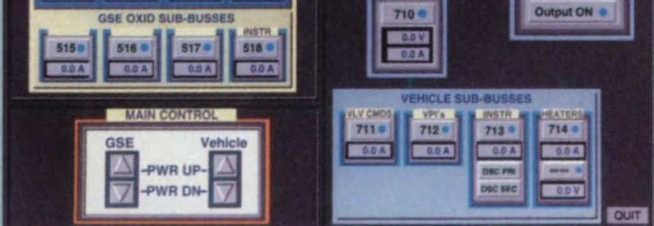
SL-GMS graphics toolkit
SL Corporation
Corte Madera, CA
415-927-1724
www.sl.com

Some of the technology installed in NASA's Kennedy Space Center's (KSC) Launch Control Center (LCC) in Florida dates back to the early days of the U.S. space program. As a result, NASA has begun an effort to modernize critical launch control systems with an eye toward safety, ease of use, upgradability, and cost-effectiveness.

The LCC, located three miles from the Space Shuttle launch pads, contains three firing rooms, each organized into clusters of computers. From these consoles, NASA engineers issue the commands that prepare the shuttles for launch.

Traditionally, engineers in the LCC have relied on custom software written in Ground Operations Aerospace Language (GOAL), which runs on custom Modcomp-based consoles. In this system, graphic images bear little resemblance to the actual systems being monitored. Launch engineers must wade through many screens of textual information in order to monitor critical data.

In 1996, NASA set out to improve the quality of the information being displayed to the launch teams. The initial focus was a production evaluation to identify the best tools to fulfill the requirement for more sophisticated, real-time graphic displays.

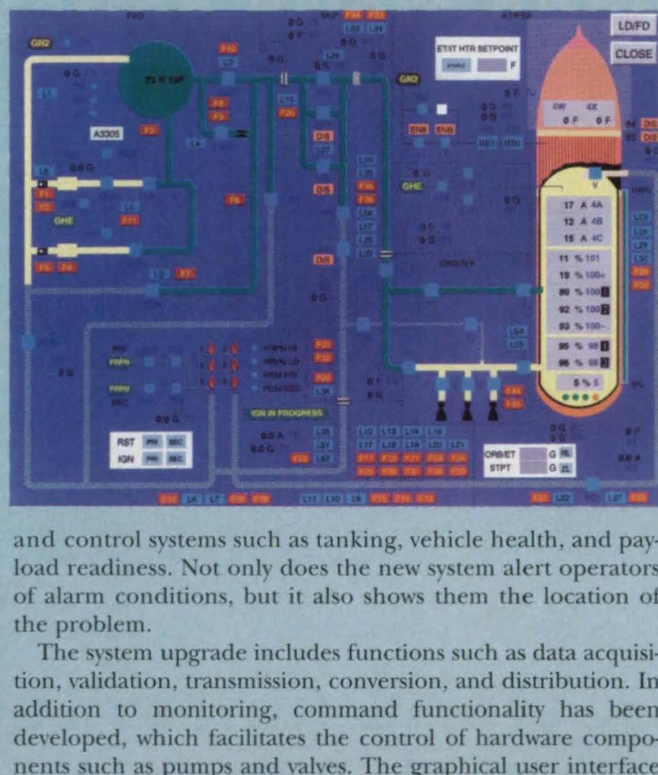


Factors in the selection process included cost and maintenance. SL-GMS was selected as the graphics toolkit for building the new front-end, real-time graphics displays. The software runs on a variety of computer platforms and operating systems, including RISC, Alpha, UNIX, and Windows NT.

Developing Displays

The graphics systems are housed in an operator console with a standard keyboard and mouse. The new computers are primarily UNIX workstations connected by a high-capacity Ethernet to data distribution computers. Monitor-only data is provided to office workstations located throughout KSC, other NASA centers, and supporting facilities across the country.

The new graphics displays provide launch engineers with a realistic view of system status. Custom graphics displays are built using a menu-driven graphical editor, which allows dynamic properties to be associated with graphical objects. The graphical attributes then can be associated with the correct driving data point. The completed model is then saved to disk and checked into a revision control system. A runtime application loads the necessary graphics and links them to real-time data. New displays have been built to monitor



and control systems such as tanking, vehicle health, and payload readiness. Not only does the new system alert operators of alarm conditions, but it also shows them the location of the problem.

The system upgrade includes functions such as data acquisition, validation, transmission, conversion, and distribution. In addition to monitoring, command functionality has been developed, which facilitates the control of hardware components such as pumps and valves. The graphical user interface built with SL-GMS provides active graphic representations of launch system components.

From Simulation to Launch

Testing and training missions benefit from using the same graphics as the actual launch control system. Simulated launches can be conducted using historical or simulated launch data. Hypothetical scenarios can be created to train launch center personnel and test the effectiveness of new graphical components.

Launch activities produce a flood of data. With the new system, all data is time-stamped at a data collection gateway, and is broadcast to a data distribution processor. Data then can be distributed to the LCC engineering groups, and can be accessed from related centers, such as Mission Control in Houston.

The modernization program is expected to boost the productivity of the NASA engineers involved in the launch process. The program also will improve the technologies involved in check-out and launching operations so that the shuttles can safely continue well into the 21st century.

For More Information Circle No. 742

Commercialization Opportunities

Imaging System With TDI and a Two-Axis-Scanning Mirror

In this telescopic imaging system, the use of a scanning mirror makes it unnecessary to rotate a relatively massive telescope. Two versions of the system were developed based on the same optomechanical design principles. Each version offers unique advantages.
(See page 30.)

NSUTCQ: an Alternative Image-Compression Algorithm

This algorithm could be especially useful for remote viewing of medical images. In telemedicine, a diagnostician could quickly view images and then request reconstruction of a more detailed view of a region of interest.
(See page 36.)

Circuit Detects Pyrolysis of Polyimide Insulation on Wires

An electronic circuit has been designed as a prototype of a device that determines whether critical electrical systems have been compromised. Circuits like this one could be beneficial in spacecraft, military and commercial aircraft, and in the nuclear power industry.
(See page 40.)

Optically Transparent Patch Antennas

These antennas can be mounted on windows of buildings and vehicles, on computer monitors, on solar photovoltaic panels, and on other convenient supports, without the use of separate antenna-supporting structures.
(See page 40.)

Sputter Deposition of Catalysts for Fuel-Cell Electrodes

Sputtering is cheaper and more amenable to mass production. Earlier methods of deposition, using ink and decals, were more wasteful of expensive catalytic electrode metals.
(See page 46.)

Organic/Inorganic Coats for Packaging of Microelectronics

Composite organic/inorganic coatings protect flip-chip assemblies at a fraction of the cost of conventional hermetic packaging. These thin conformal coats are alternatives to heavier, bulkier hermetic packages.
(See page 46.)

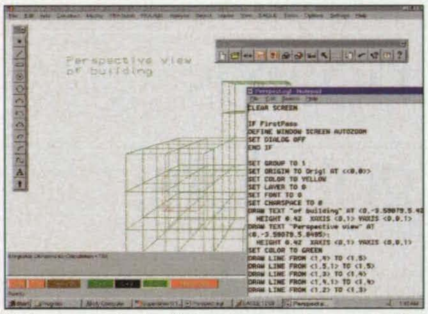
Boundary-Layer Rake of Pitot Tubes for Flight Testing

Results of tests show that this rake exhibits good aerodynamic performance and that it is operationally rugged, thanks to a curved rake body — a feature that makes it possible to cluster the pitot tubes in the near-wall region more densely than in conventional rakes.
(See page 48.)

Algor for Finite Element Analysis

Steven S. Ross

Welcome to Algor 12, the third stage in the development of finite element analysis. Young engineers might not realize it, but the whole concept of finite element analysis — where surfaces and solids are divided into small pieces, and stresses are analyzed at the edges where pieces meet — is quite new. It was invented in the 1950s and not widely used until the 1970s. Even then, it was not to be depended upon for super-accurate results.



This shot of a building frame shows, in the box, the simulation program generated by the software.

First-generation packages offered a brute-force way of analyzing stress on moderately complex components. Second-generation packages made FEA interfaces easy enough to use that most engineers could do FEA, even if they didn't know enough to avoid serious pitfalls.

All through 1999, Algor has been adding pieces to what amounts to a third generation: a package that helps keep designers from making serious errors, most of the time. You still have to know a lot, to keep from blundering. But the improvements add up to real progress. Algor's Release 12 features:

- Superdraw III, an improved drafting and data-entry package. We found it a delight to use for defining small assemblies, even assemblies with complex parts. Think of it as CAD with a brain.
- New element types including hydrodynamic and kinematic elements for modeling fluids and solids in relative motion to larger assemblies.
- A new database that holds variables in whatever units and numerical formats you wish.
- A new Material Library Manager that allows easy editing and storage of materials properties.
- General von Mises and 3-D viscoelastic material models for nonlinear analysis (usually, of materials stressed beyond their yield points). These techniques take FEA to new levels, and Algor makes them fairly easy to implement.
- Better tools for generating surface and solid "meshes" that break components into "finite elements" for analysis in the first place. There's even a "no pyramids" option that provides meshes in transition areas between parts or different cross sections without resorting to irregular triangular mesh shapes — ideal for easier export to third-party packages.
- Due soon is a link between Algor and most solid modeler CAD software that supports Microsoft's COM (OLE). FEA will show up as a menu choice inside the modeler, allowing you to create meshes without converting the CAD files to a standard intermediate format such as IGES first. The mesh can then be saved as an Algor geometry file.

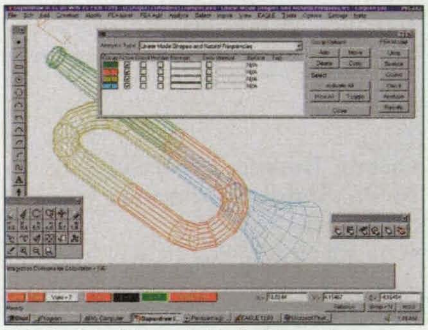
How does it all fit together? Remarkably well, although you do have to pay attention. Algor's system throws off many different file types; it takes awhile to get comfortable with what each new item is, in your project directories. For this review, I had a ready-made problem left over from a story I had done five years ago on the lack of testing of subway-car wheels by the New York City subway system. The S-profile wheels were 700 pounds each, or about 100 pounds lighter than the standard straight-profile wheel.

Using FEA, mechanical and thermal stresses on such a wheel are calculated fairly easily. But because the thermal gradients (and thus the stresses they can cause) propagate far more slowly through the steel wheel than do the mechanical strains and stress, FEA packages of the day could not simulate what would happen to the wheels in actual use.

I started with a DXF file of the wheel's profile, imported it into AutoCAD 2000 and swept it around 360 degrees in 3D space to generate a model of the entire wheel. I then brought the model into Algor and processed it twice — once for mechanical stress and once for thermal. I also brought the profile into Superdraw III and generated the solid that way, with about the same result.

Algor's materials library had the data I needed on the steel. I had to modify it slightly for my specs. Algor has FEA processors for both mechanical and thermal analysis. And Algor's new data entry screens reduced the risk of entering entirely silly values for the analysis.

In general, everything happens faster, too. For many problems, for instance, you will want to model one new part in a larger assembly. The pieces other than the one you are modeling can be set up with the new "kinematic" elements. Stresses within those parts won't be modeled — Algor will calculate only the forces that it generates on the part you are modeling. The process is intuitive as you set up the model in Superdraw.



This shot depicts analysis of a trumpet.

All of this costs anywhere from a bit under $2,000 to $20,000 or more, depending on your needs. Typically, you might think of budgeting $10,000 for software and training materials, and maybe for an online course, delivered over the Web. There are versions available for Pentiums running Windows 95, 98, and NT, as well as some UNIX boxes. Check the website at www.algor.com for details. Memory requirements will vary, depending on the speed you want and the operating system. Algor recommends at least 32 to 64 MB. We suggest 128 MB as a more realistic minimum.

Steve Ross teaches journalism at Columbia University in New York City, where he directs the science writing program.

Cast Your Vote for

NASA TECH BRIEFS

Fifth Annual Readers' Choice Awards

Each month, *NASA Tech Briefs'* UpFront editor's page features the Product of the Month — a new product with exceptional technical merit and practical value to our more than 200,000 engineering and management readers.

This month, we invite you to vote for the one product among those highlighted throughout 1999 that you feel was the most significant new product introduced for the engineering community this year. The product receiving the most votes will be named *NASA Tech Briefs* 1999 Readers' Choice Gold Winner for Product of the Year. The products with the second and third highest number of votes, respectively, will be awarded the Silver and Bronze awards.

Last year's winner of the Gold Award was LabVIEW Version 5.0 graphical instrumentation software from National Instruments of Austin, TX.

On the facing page are descriptions of each of the Products of the Month chosen in 1999. Choose the **one** product you feel should receive Product of the Year honors, and cast your vote in one of the following ways:

- Visit the *NASA Tech Briefs* web site at **www.nasatech.com** and indicate your choice on the Product of the Year ballot;
- Complete the ballot below and fax it to the Editor at: 212-986-7864; or
- Mail the ballot to: Product of the Year, *NASA Tech Briefs*, 317 Madison Ave., Ste. 1900, New York, NY 10017.

Only one vote per person will be counted. Your completed ballot must be received by January 28, 2000. All eligible voters will be entered in a random drawing to win valuable prizes contributed by past winners of Readers' Choice Awards.

The 1999 Readers' Choice Awards will be announced on March 13, 2000, during National Manufacturing Week in Chicago. We'll also list the winners in the April issue of *NASA Tech Briefs*, and on our web site at www.nasatech.com.

1999 *NASA Tech Briefs* Readers' Choice Product of the Year Ballot

Name: ______________________________

Company: ______________________________

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Check only one box

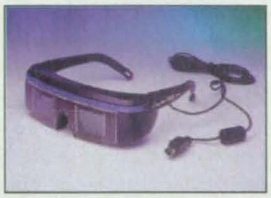
- ❑ **January:** SGI – 320/540 Windows-based workstations
- ❑ **February:** Visionary Design Systems – IronCAD Version 2.0 CAD software
- ❑ **March:** Hewlett-Packard – HP 16600A/16700A logic analyzers
- ❑ **April:** StereoGraphics – CrystalEyes Wired stereoscopic eyewear
- ❑ **May:** Engineering Services Data Unit (ESDU) – ESDU engineering database
- ❑ **June:** Parker Hannifin – Spectrum Series couplings
- ❑ **July:** Endevco Corp. – OASIS 2000 sensor interface system
- ❑ **August:** Wolfram Research – *Mathematica* 4 technical computing software
- ❑ **September:** Gage Applied Sciences – CompuScope 1602 A/D converter card
- ❑ **October:** Spatial – 3Dmodelserver.com web-based model repair
- ❑ **November:** Invention Machine Corp. – CoBrain knowledge processing database
- ❑ **December:** Compaq Computer Corp. – Deskpro AP240 professional workstations

Product of the Year Nominees

SGI, Mountain View, CA, introduced the 320 and 540 system visual workstations, the company's first line based on the Windows NT operating system. The 320 is a mini-tower workstation that can be configured with up to two Intel Pentium II 450-MHz processors, and can support up to 1 GB of memory. The 540 systems are full-tower, quad-capable Pentium Xeon workstations that can be configured with up to four Xeon 450-MHz processors.

Version 2 of IronCAD mechanical engineering software from Visionary Design Systems, Santa Clara, CA, offers drag-and-drop sheet metal part creation, new object manipulation functionality, improved 2D profile creation, and enhancements to its data translation and surface-to-solid capabilities. Handles, including SmartSnap®, and a dynamic 3D constraint solver, allow users to perform sizing and positioning operations, regardless of how the model originally was dimensioned.

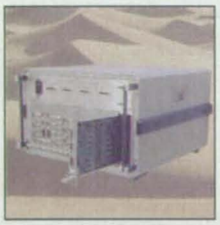
Hewlett-Packard, Palo Alto, CA, offers the HP 16600A and 16700A Web-enabled, remote-control logic analyzers. The systems feature Web-server capability, allowing users to access an HP logic analyzer over the Internet or through an intranet using Version 4.0 or higher of Microsoft Internet Explorer or Netscape Communicator. Users can check the status of a logic analysis session without being anywhere near the analyzer. PC users can move data from a logic analyzer onto a Microsoft Excel spreadsheet.



CrystalEyes Wired is an entry-level stereoscopic eyewear system from StereoGraphics Corp., San Rafael, CA, for CAD, mechanical design, and scientific professionals who work with complex 3D images. The system is designed for Windows NT-based graphics software users and developers for virtual prototyping, design, and simulation. The user plugs the eyewear into a compatible graphics card.

Engineering Sciences Data Unit (ESDU) International, Englewood, CO, released the ESDU database of mechanical, process, and structural engineering data items in electronic format, on the Internet and CD-ROM. The database contains more than 1,250 data items in 230 volumes. Each volume contains data items covering a specific engineering problem or component; data items may be methods, data examples, programs, or equations.

The Spectrum Series couplings from Parker Hannifin, Minneapolis, MN, combine compact size, high flow capability, and lightweight design for a variety of coupling applications. The series is available in three material options: Acetal, PVDF, and PVDF+. The couplings all feature a push-to-connect design, and have a variety of port options.

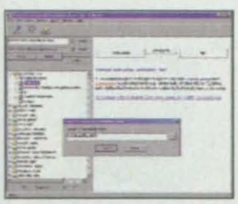


Endevco Corp., San Juan Capistrano, CA, offers the OASIS 2000 sensor interface system, a computer-controlled, multi-channel measurement instrumentation system that provides an interface to a data acquisition system for a variety of sensors, including strain gauges, pressure sensors, and accelerometers. The system incorporates four cards, which mount into a 16-slot Model 4990 EIA 19" rack.

Mathematica 4 technical computing software from Wolfram Research, Champaign, IL, combines calculating capabilities with a collection of visualization and technical publishing tools. New features include speed enhancements; direct import and export from over 20 standard data, graphics, and sound file formats; and extended HTML and TeX output. The software supports computations in specified algebraic domains, and features improved data analysis functions.

Gage Applied Sciences, South Burlington, VT, introduced the CompuScope 1602 single-slot, 16-bit A/D and Scope card for the PCI bus that is capable of dual-channel, simultaneous conversion rates to 2.5 MS/s. The card operates in two modes: Memory Mode, with up to 8 million samples of acquisition memory; and Real Time Mode, in which it can stream data to host memory for up to 1 billion samples of acquisition memory.

Spatial, Boulder, CO, announced 3Dmodelserver.com, a Web-based software application for repairing and improving 3D models. The application enables the use of models across multiple, heterogeneous software applications, making them more usable in design, analysis, and manufacturing. The service can be accessed using any Web browser and Internet connection, and can be updated on a daily basis.



CoBrain knowledge processing software from Invention Machine Corp., Boston, MA, allows users to semantically process large numbers of electronic documents from internal and external sources, including research reports, patents, conference proceedings, and technical journals. It extracts and presents an index of technical documents displayed in a problem-solution format.

Compaq Computer Corp., Houston, TX, introduced the Deskpro AP240 professional workstations, designed to serve as a bridge between the company's high-end Deskpro units and entry-level workstations. The desktop and mini-tower systems feature single Pentium III 600EB and 733-MHz processors in the Rambus-memory-based models, and single Pentium III 700-MHz processors in the SDRAM-memory-based models. The Rambus-based models also feature Intel's 820 chipset, and maximum memory of 1 GB.

Books & Reports

Updates on Optical Diagnosis of Fuel Spray Patterns

A collection of three reports presents an expanded discussion of the topic of "Optical Diagnostics of High-Pressure Liquid Fuel Sprays" (LEW-16701), *NASA Tech Briefs,* Vol. 23, No. 3 (March 1999), page 18a. The reports describe experiments in which fuel sprays representative of those in liquid-fueled, high-pressure gas turbine combustors were analyzed by a combination of planar laser-induced fluorescence imaging, planar Mie scattering, and phase Doppler particle analysis. The earliest of the reports ("Fuel Injector Patternation Evaluation in Advanced Liquid-Fueled, High-Pressure, Gas Turbine Combustors, Using Nonintrusive Optical Diagnostic Techniques") was the subject of the noted prior article.

This work was done by Yolanda R. Hicks, Robert C. Anderson, and Michelle Zaller of **Glenn Research Center** *and Randy J. Locke of Dynacs Engineering Co., Inc. To obtain copies of the reports and the summary document, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16882.

Time-Parallel Solutions of Linear PDEs on a Supercomputer

A paper describes the mathematical basis and some applications of a class of massively parallel algorithms for finite-difference numerical solution of some time-dependent partial differential equations (PDEs) on massively parallel supercomputers. In a radical departure from the traditional spatially parallel but temporally sequential approach to solution of finite-difference equations, the algorithms described in the paper are fully parallelized in time as well as in space: this is achieved via a set of transformations based on eigenvalue/eigenvector decompositions of matrices obtained in discretizing the PDEs. The resulting time-parallel algorithms exhibit highly decoupled structures, and can therefore be efficiently implemented on emerging, massively parallel, high-performance supercomputers.

This work was done by Nikzad Toomarian, Amir Fijany, and Jacob Barhen of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Time Parallel Solutions of Linear Partial Differential Equations on the Intel Touchstone Delta Supercomputer," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. NPO-19385*

Quick Guide to MSAT

A report presents additional information on the Mechanical System Design/Analysis Tool (MSAT) computer program, which was reported in "Program for Designing a Mechanical System" (LEW-16710, *NASA Tech Briefs,* Vol. 23, No. 9 (September 1999), page 32. To recapitulate: MSAT is a user-friendly, multidisciplinary software system that facilitates and accelerates the synthesis and analysis of designs of mechanical systems. MSAT features a modular architecture that organizes design-analysis tasks around object-oriented representations of (1) components of an aircraft engine or other system that one seeks to design, (2) analysis programs, and (3) data-transfer links among the components and analysis programs.

This work was done by HuaHua Lee, Mark Kolb, and Jack Madelone of General Electric Co. for **Glenn Research Center**. *To obtain a copy of the report, "Mechanical System Analysis/Design Tool (MSAT) Quick Guide," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
LEW-16888

Forward-Scattering Particle-Image Velocimetry

Using only one line of sight, one can measure three-dimensional velocity.

John H. Glenn Research Center, Cleveland, Ohio

Forward-scattering particle-image velocimetry (FSPIV) is a technique for measuring velocities in microscopic flow fields as thin liquid films. As in other particle-image-velocimetry (PIV) techniques, the velocity of a flow is computed from temporally changing images of suitably illuminated, neutrally buoyant particles entrained in the flow. Unlike other PIV techniques, (1) particles are back-illuminated with coherent or partially coherent light, (2) a microscope is used to resolve forward scattering of light from the particles, and (3) all three components of velocity can be measured from only one line of sight, without readjustment of optics.

Figure 1 illustrates a laboratory setup for FSPIV. Illumination is provided by a microscope-illumination source equipped with a wavelength-selective filter. Partial coherence is obtained by closing the aperture on the illumination source. Microscopic spherical seed particles of known diameter are suspended in the liquid. A transmitted-light microscope is aimed through the cell back toward the source and is focused to a suitable depth within the cell. Forward-scattered light from a particle in the field of view of the microscope is brought to focus on the microscope image plane to obtain a magnified image of the particle. A charge-coupled device (CCD) is mounted at the image plane to acquire the image. The CCD output is digitized, then processed as described below to extract information about the three-dimensional velocity of the particle.

Coherent illumination is needed because it makes the forward scattering of light (including such effects as diffraction from particles and phase changes in microscope lenses) amenable to analysis. Highly coherent illumination like that provided by a laser results in speckle noise; partially coherent illumination is preferred in this application because it can yield diffraction patterns adequate for analysis while generating much less speckle noise.

Figure 2 schematically illustrates how images are processed to extract velocities. First, a frame of image data is acquired at a known sampling time. Next, the image of each particle is separated from other particles. The scattering pattern for each particle is analyzed to determine the distance of the particle, relative to the focal plane, along the line of sight. This aspect of the analysis involves comparisons of the observed scattering pattern with scattering patterns that have been computed theoretically and/or recorded experimentally for known positions relative to the focal plane. The comparisons and the interpolations between known positions can be performed by neural-network software that has been trained on the known scattering patterns. Then the component of velocity of each particle along the line of sight is calculated as the distance between two positions

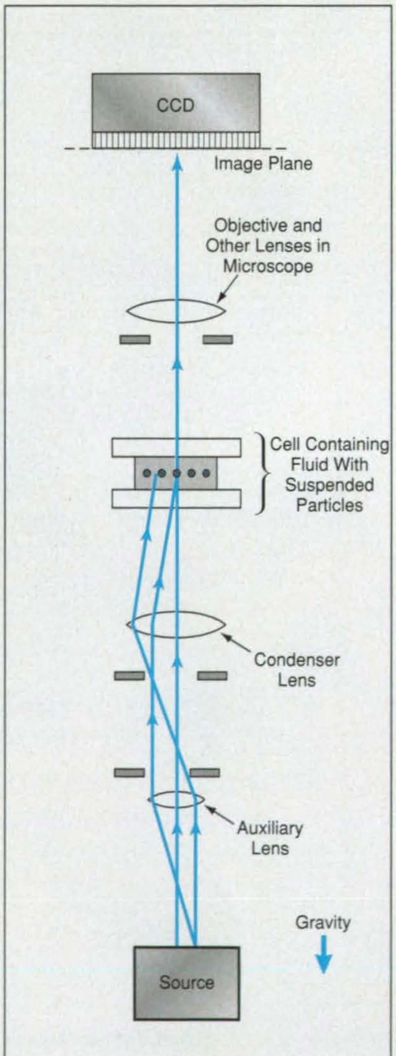


Figure 1. A **Microscope Resolves Forward Scattering** of partially coherent light from particles suspended in a fluid. The magnified image is captured by a CCD.

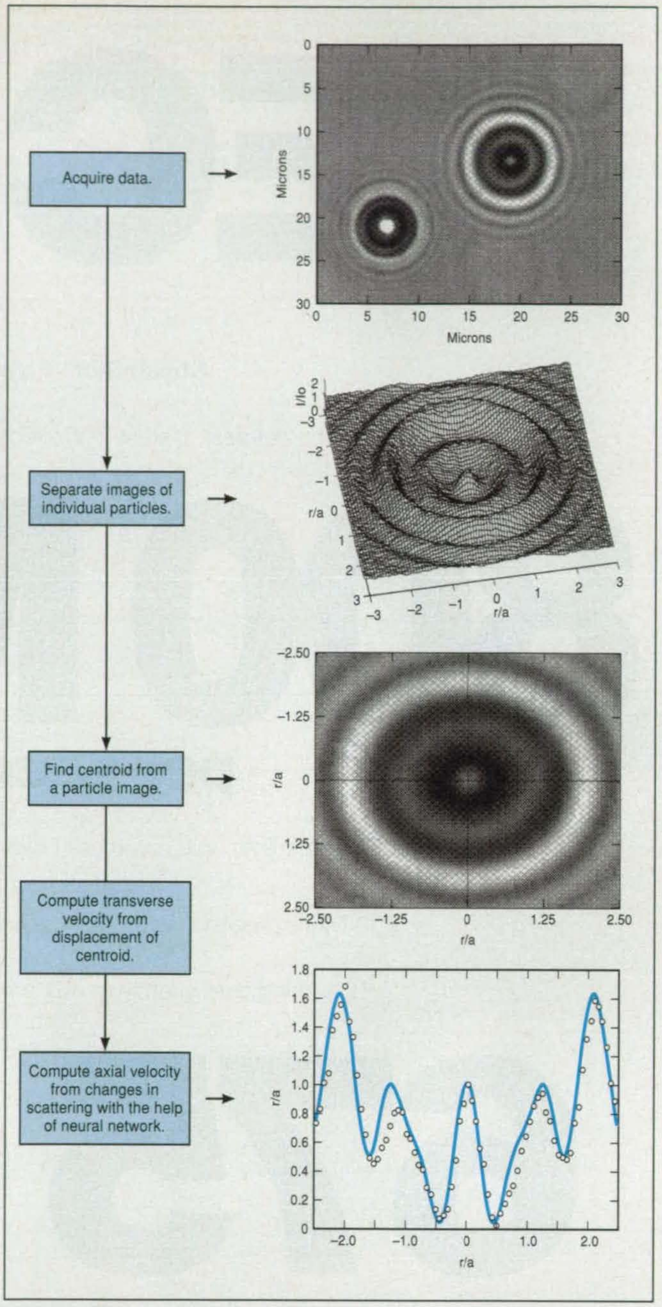


Figure 2. **Magnified Images of Particles** in forward-scattered light are processed to extract data on three-dimensional velocity.

determined in this way for two sampling instants, divided by the time between the instants.

The components of velocity in the plane perpendicular to the line of sight are determined by tracking particle-image centroids as they move across the field of view between successive frames. The tracking of particle-image centroids as a function of time is an established PIV practice; techniques for tracking particle-image centroids as functions of time have been reported in a number of previous articles in *NASA Tech Briefs*. An added benefit of FSPIV is that the scattering is centro-symmetric so that the centroid is found with high accuracy.

This work was done by Ben Ovryn of NYMA, Inc., and John D. Khaydarov of Ohio Aerospace Institute for **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16403.

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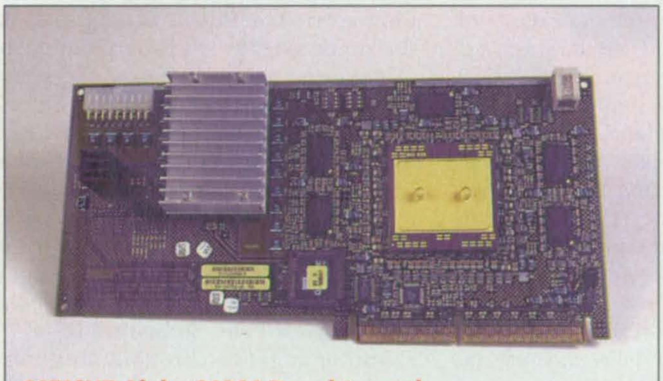
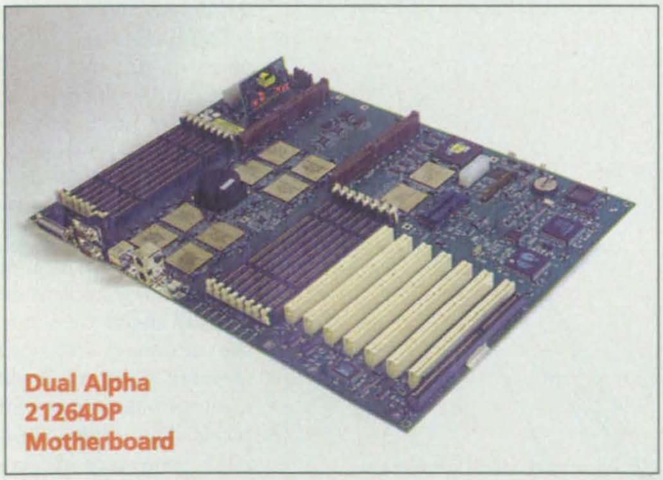


667MHZ Alpha 21264 Daughtercard



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For more information, contact Microway, Inc., Research Park, Box 79, Kingston, MA 02364; Tel: 508-746-7341; Fax: 508-746-4678; e-mail: info@microway.com; www.microway.com

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Imaging System With TDI and a Two-Axis-Scanning Mirror

A unique optomechanical scanning subsystem offers several advantages.

Goddard Space Flight Center, Greenbelt, Maryland

A telescopic imaging system that includes an optomechanical scanning subsystem is undergoing development. The system is designed for use in scientific observation of the Earth from aboard a satellite in geostationary orbit. The basic principles of the optomechanical scanning subsystem may also be applicable to special-purpose terrestrial optical instruments.

The principal optical component of the optomechanical subsystem is the scanning mirror — a flat mirror with an elliptical cross section. The mirror is rotated about two mutually perpendicular axes to scan the focal plane of the telescope in a raster pattern that defines a field of regard that extends across the surface of the Earth and into adjacent areas of dark space (observations of adjacent dark space provide instrument background readings that can be subtracted from Earth-surface readings). The use of the scanning mirror makes it unnecessary to rotate the relatively massive telescope to scan this field of regard, which is wider than the field of view of the telescope. The use of a scanning mirror for such a purpose is not new or unique; instead, the unique aspect of the optomechanical subsystem lies in some of the particulars of its design.

The system (see Figure 1) is most readily characterized by reference to a Cartesian coordinate system. The central line of sight of the field of regard is along the nadir (the z axis). In the first version of the system, the optical axis of the telescope is parallel to the south (y) axis; in the second version, the optical axis of the telescope is tilted 30° from the y axis in the y,z plane. The image is detected on a focal-plane array (FPA) of photodetectors arranged in rows of pixels along the x axis. The along-scan (east–west rapid-scan) component of the raster pattern corresponds to motion of the focal spot along a row of pixels in the x direction. The FPA-readout scheme is based partly on time delay and integration (TDI); this produces a requirement that the optomechanical-scanning velocity be constant and equal to the electronic-scanning velocity so that the packet of charge from each pixel on the FPA will correspond to a line of sight to a single spot in the scene.

The scanning mirror is mounted on a gimbal with two perpendicular axles. The outer axle is attached to the telescope body and is parallel to the x axis; this axle is used to generate the cross-scan component of the raster pattern (north-to-south steps between scanning arcs). The mirror is mounted on the inner axle, which is perpendicular to the outer axle and is used to generate the rapid east–west scan component. In the first version of the system, the angle, Θ, between the telescope's optical axis and the inner axis of the scan mirror is 45° at the center of the raster patten, and decreases from 49.35 to 40.65° as the line of sight (LOS) is scanned from the North Pole to the South Pole (from +8.7 to –8.7° elevation at geosynchronous altitude). In the second version of the system, the angle Θ is 60° at the center of the raster pattern and decreases from 64.35 to 55.65°.

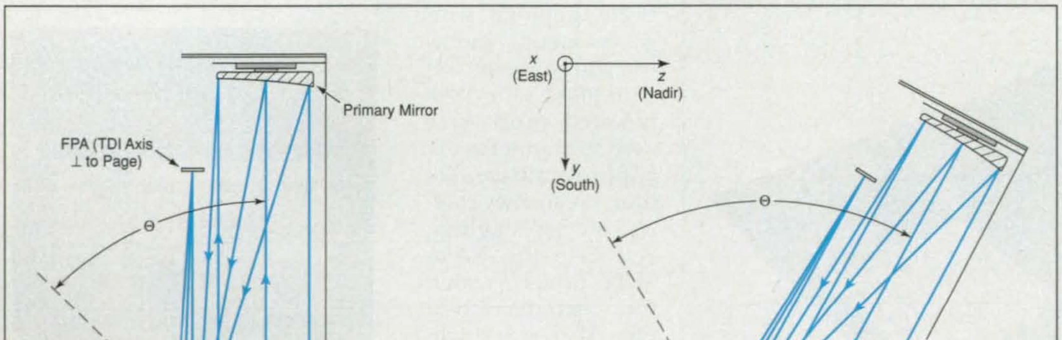

Figure 1. **Both Versions of the System** are based on the same optomechanical design principles. The second version offers some advantages over the first version.

The along-scan components of the raster pattern can be described as a series of predominantly east–west arcs separated by small cross-scan north–south intervals (see Figure 2). Each arc is scanned by rotation of the inner axle at constant angular speed to obtain the required constant speed of scanning of the focal spot along a row of pixels. The outer axle is held stationary during the motion along each arc. At the end of each arc, the outer axle is actuated to index to the next north–south position and the arc at that position is scanned along a reverse path by rotating the inner axle in the opposite direction.

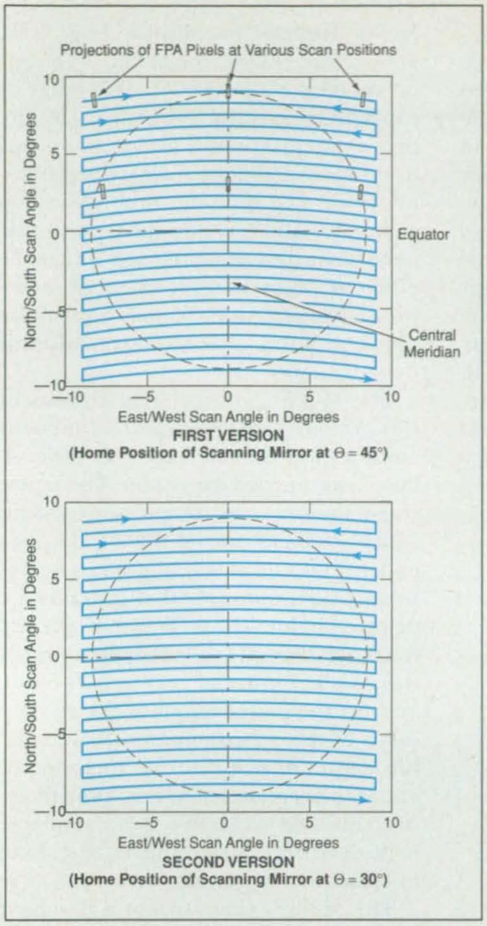

Figure 2. The **Earth and Nearby Space Are Scanned** in a series of predominantly east–west arcs separated by small north–south intervals. By virtue of the different instrument geometry, the arcs in the second version are more nearly straight lines.

The angular velocity of the LOS equals the rotational velocity of the inner gimbal axis, $d\Psi/dt$ multiplied by $2\sin(\Theta)$. The value of $2\sin(\Theta)$ decreases on each consecutive arc from north to south, so $d\Psi/dt$ must be increased from arc to arc. The image of the FPA rotates so that its TDI axis always coincides with the scan velocity, and its cross-scan axis (the long axis) is always perpendicular. (Refer to the top arc in Figure 2.)

The second (30°) version offers several advantages over the first (45°) version:

- The angle of reflection is smaller; consequently, the reflection introduces less spurious polarization.
- The major axis of the mirror ellipse can be made shorter, thereby reducing the mass and angular momentum of the mirror.
- Rotation of the image (equivalently, rotation of the projection of the FPA pixels onto the scene) is less.

This work was done by James C. Bremer of Swales Aerospace for **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at*** *www.nasatech.com under the Physical Sciences category.*
GSC-14088

M-JPEG Video Compression System for Space-Based Applications

This video-compression/decompression system meets the unique demands of space-based applications.

Lyndon B. Johnson Space Center, Houston, Texas

An M-JPEG video compression system has been modified to satisfy the unique requirements of space-based applications. ["M-JPEG" signifies the still-image-data-compression method of the Joint Photographic Experts Group (JPEG) as applied to moving (e.g., video) images.] This ruggedly constructed, modular system is compatible with NASA interfaces and meets Agency requirements for reduced size, weight, and power. The M-JPEG system generates test patterns, enables users to select compression characteristics and desired output rate, is inexpensive to modify and upgrade, and has features that are adaptable to mission-specific requirements.

Two categories of video compression/decompression systems are commercially available: (1) computer-based video compression/decompression systems for multimedia applications and (2) stand-alone box compression/decompression systems for broadcast applications. None of these systems satisfies the requirements for all of NASA's unique applications. The sizes, weights, and power demands of commercial video systems are too high. Commercially available systems also do not provide compatible interfaces or compression options that users can select and control from front panels, and they do not generate test patterns. Moreover, most commercial compression/decompression systems are not ruggedly constructed or modular in design, many do not provide adequate video quality, and

none is capable of adjustment to any desired output rate. Finally, the cost of retrofitting any of these systems to satisfy NASA requirements is prohibitive. To summarize: While the video compression/decompression systems currently in use satisfy the commercial industry requirements for which they were designed, they fail to meet NASA's unique requirements for space-based applications.

The M-JPEG system has been designed to perform functions specific to space flight. It was modified to enable it to perform the following functions: digitize a standard SMPTE-170M National Television Systems Committee (NTSC) signal using a variety of programmable color spaces; compress a digital video signal using an adaptive M-JPEG compression algorithm; enable the user to select compression modes and thereby modify compression parameters; packetize the compressed digital video signal for transport; provide both a fiber-optic and an electrical [emitter-coupled logic (ECL)] output interface; receive the compressed digital video signal, decompress the data, and produce an acceptable version of the original noncompressed digital video signal; and convert the decompressed digital video to a variety of formats for display [e.g., red, green, blue (RGB), composite NTSC, or component NTSC (Y/C)]. This range of capabilities enables NASA to: (1) improve the quality of video transmissions over that of standard analog video transmissions, (2) transmit multiple video channels within bandwidths previously needed for one channel, and (3) make efficient digital recordings of compressed digital video signals and multiple-generation recordings without degradation.

The M-JPEG video system consists of two primary subsystems: the onboard compression system and the ground-based decompression system. The figure shows the onboard compression system, which contains the M-JPEG video encoder. This encoder is housed in an anodized aluminum case that contains the printed-circuit boards (PCBs). There are four such PCBs: (1) a video digitizer, (2) the M-JPEG encoder, (3) a packetizer, and (4) the power supply. Many components of this subsystem are programmable logic devices; these include an erasable programmable read-only memory (EPROM), erasable programmable logic devices (EPLDs), and a stand-alone microsequencer (SAM).

The M-JPEG video system is designed to interact with either the high-frame-rate multiplexer (HRFM) of the International Space Station or with a space shuttle multiplexer. Because of the modular design of the onboard compression system, three of the PCBs — the video digitizer, the M-JPEG encoder, and the power supply — can be retained in their original state, while an alternate communication circuit can then be employed instead of the packetizer to serve as an interface with another system.

The ground subsystem consists mainly of three personal computer (PC) advanced technology (AT) Industry Standard Architecture (ISA) boards. The user connects the display circuit to either a red/green/blue (RGB) NTSC monitor or to a composite NTSC or component Y/C monitor, depending on which of the two display circuits is being used. Several programs are utilized to initialize the PC AT boards and run the ground system. Programs have been written to read the telemetry data to determine the configuration of the onboard system. The settings of the ground-system boards can be read to ensure that the proper configurations and frames can be captured whenever the user wants to import an image into the ground computer. (The current file format for imported images is the Targa 24 image file format.) Because of the limitations of the PC AT ISA bus and the enormous amount of stor-


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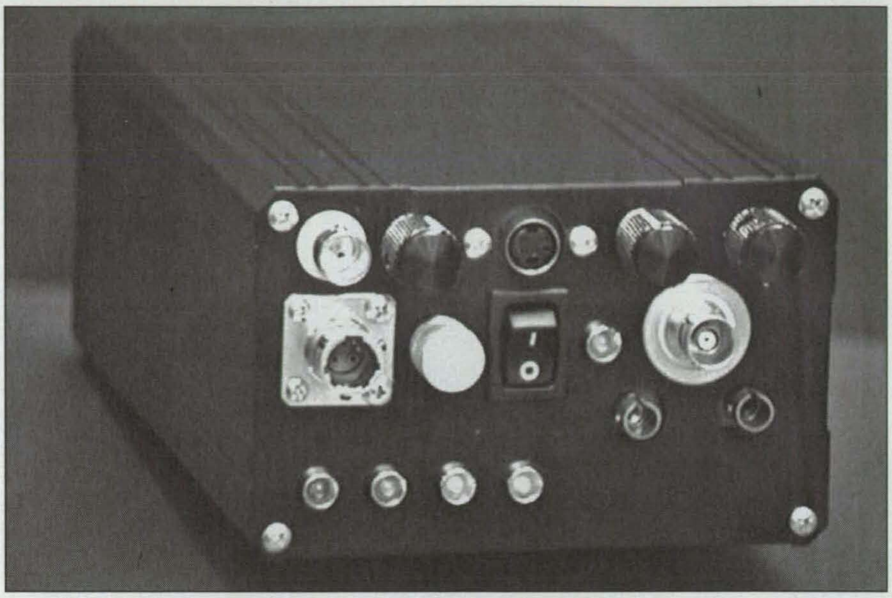
age capacity needed to store even a short video sequence of the required quality, the system does not allow storage of compressed motion video data in the ground computer. The M-JPEG video system can be used to provide broadcast-quality video to an existing analog video ground distribution system or, preferably, to a digital video ground distribution system. Decoding is done at the end viewing location.

The M-JPEG video is flexible enough to be amenable to modification] to satisfy a variety of requirements and to suit various applications. For example, computer interfaces could be changed to enable the use of the ground-based components of the system with alternate computers. Inasmuch as the on-board system is modular, it can be modified for different interfaces, as for different communication protocols. A system currently under development — the Moving Pictures Expert Group (MPEG) 2 codec — will incorporate the video digitizer and packetizer from the M-JPEG system, but the encoder board will be replaced with circuitry that implements an alternate compression algorithm.



The **Compression Subsystem of the NASA M-JPEG Video System** contains the M-JPEG video encoder plus a video digitizer, a packetizer, and a power supply.

While the concepts included in the design of the M-JPEG video system are not new, specific implementations of the design are new. The combination of existing techniques and equipment is unique and satisfies the similarly unique requirements of NASA's space-based applications.

This work was done by S. Douglas Holland of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
MSC-22744

Low-Absorption Color Filters for Flat-Panel Display Devices

Reflected light would be reused to obtain brighter displays.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed technique for color filtering in a liquid-crystal or other flat-panel display device would make it possible to brighten the display without increasing the amount of light supplied from behind the panel. The need for the proposed technique arises as follows: At present, each pixel in a typical color liquid-crystal display device contains three dye filters: red, green, and blue. Each filter transmits its single primary color and absorbs the other colors, so that less than one-third of the available light is used for viewing. In addition, the liquid-crystal display uses polarized light, so that half of the incident unpolarized illumination is necessarily wasted. The net result is that less than one-sixth of the incident unpolarized light is utilized. One does not have the option of increasing the illumination substantially to brighten the display because the increase in heat generated by absorption of light in the filters could harm the display device.

In the proposed technique, one would replace the dye filters with surface-plasmon or interference filters, which are more reflective than absorptive. In addition, the fil-

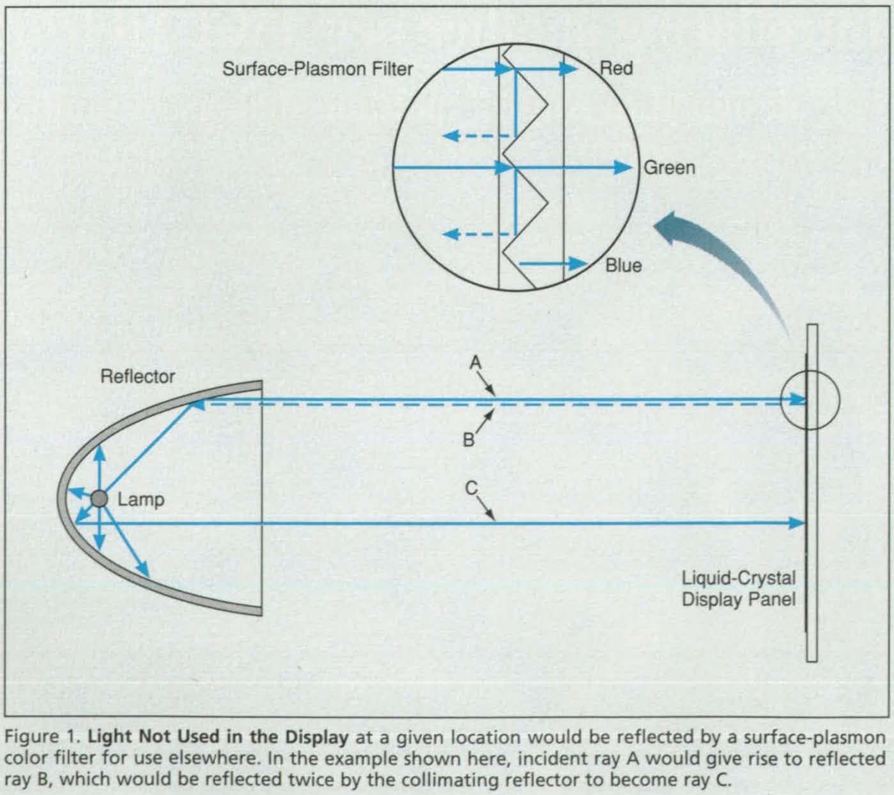


Figure 1. **Light Not Used in the Display** at a given location would be reflected by a surface-plasmon color filter for use elsewhere. In the example shown here, incident ray A would give rise to reflected ray B, which would be reflected twice by the collimating reflector to become ray C.

ter and illumination optics would be arranged so that much of the light reflected from the filters would be reused as illumination. The overall effect should be an increase in brightness and efficiency.

Figure 1 illustrates this concept as applied to a liquid-crystal panel back-lit by a lamp with a collimating reflector. Light reflected from a color filter on the panel would return to the collimating reflector, where it would be reflected twice and sent to a different location on the panel. Of course, neither the original light from the lamp nor the light reflected from the panel would be collimated perfectly as shown in simplified form in the figure; all incident and reflected beams of light would have some angular spread. This spread would be beneficial in that it would make the illumination more nearly uniform across the panel.

Figure 2 shows a proposed configuration of an in-pixel surface-plasmon color filter, which would contain long, narrow microprisms in odd-numbered rows and shorter prisms oriented perpendicularly to them in even-numbered rows. Light that was p- or s-polarized to the longer prisms would be s- or p-polarized, respectively, to the shorter prisms. Each prism would pass light of only one polarization and reflect light of the other polarization. Thus, the polarized light not utilized in each pixel would be sent back to the collimating reflector and redistributed elsewhere on the panel, where some of it would be utilized in other pixels.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20435

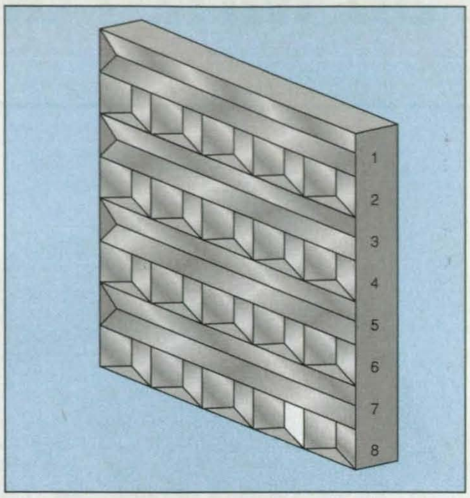


Figure 2. **Alternating Rows of Microprisms** in a surface-plasmon color filter in a pixel would transmit and reflect light in mutually orthogonal polarizations. This arrangement would make it possible to utilize both polarization components of unpolarized light, whereas heretofore, only one of them has been utilized.

NSUTCQ: an Alternative Image-Compression Algorithm

This algorithm could be especially useful for remote viewing of medical images.

John H. Glenn Research Center, Cleveland, Ohio

No-shift universal trellis-coded quantization (NSUTCQ) is an image-data-compression/decompression algorithm designed to be especially useful in telemedicine. Like some other image-compression/decompression algorithms, this one provides both (1) lossy compression/decompression for transmission of most of the information in an image subject to competing requirements to limit transmission time, transmission bandwidth, and image distortion and (2) lossless (or constrained-loss) compression/decompression for transmitting the residual information (the remainder of the information necessary for reconstruction in full detail) about regions of interest (ROIs) within images. Thus, in telemedicine, a diagnostician could preliminarily view less-detailed versions of images, then select ROIs that appear to be significant and request reconstruction of the fully detailed versions of the ROIs.

This **X-Ray Image of a Hand** was digitized and its data compressed by a factor of 62 before reconstruction. The two regions of interest delineated by white rectangles were compressed by the residual-encoding scheme and therefore exhibit sharper detail than do surrounding areas.

The NSUTCQ algorithm is a modified version of a previously developed lossy compression/decompression algorithm called "adaptive wavelet/universal trellis-coded quantization" ("wavelet/UTCQ" for short). The wavelet/UTCQ algorithm begins with the use of a wavelet decomposition to transform gray-scale images into wavelet coefficients. The wavelet decomposition can be followed by an adaptive subblock classification to improve coder performance. Next, the wavelet coefficients in the subblock are quantized. The quantization subalgorithm can be characterized as a highly structured vector quantizer or as a scalar quantizer with memory. The quantizer processes the wavelet coefficients into quantization indices. The quantization process is lossy; that is, it introduces distortions into the wavelet coefficients. The goal in designing a good quantizer is to ensure that the distortions do not seriously degrade the reconstructed imagery. In the wavelet/UTCQ algorithm, the quantization indices are adaptively arithmetically encoded in an eight-state trellis-coded quantization (TCQ) scheme.

The NSUTCQ algorithm differs from the UTCQ algorithm in two major respects:

1. Changes in the quantizer, involving codebook structures, probability models, and other mathematical considerations too complex to be described here, reduce the sizes of the quantization steps. Absolute errors should therefore be smaller.
2. A subalgorithm that involves a defined error tolerance and binning with adaptive arithmetic encoding of residual values for ROIs has been added. The figure is an example of a reconstructed image with two residual-encoded ROIs.

The UTCQ and the NSUTCQ algorithms both have their places in an image-compression/decompression scheme in that their capabilities are

complementary. The NSUTCQ performs better at high bit rates. An examination of bit-rate allocations made by an experimental encoder that implements both algorithms revealed that low-frequency subbands were compressed at high bit rates while high-frequency subbands were compressed at low bit rates. Therefore, it makes sense to use both quantizers, choosing the one that best suits the wavelet subband being quantized.

This work was done by Jim Kasner of Optivision Inc. for **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16667.

Software for Scanning, Storing, and Retrieving Images

John F. Kennedy Space Center, Florida

An application program for scanning and storage of images and for retrieval of the images via the World Wide Web has been written in the Java programming language to be portable to any computer and operating system that support the Java Virtual Machine 1.02. The program can be run on one computer or spread across three computers: a client, a server, and a third computer that stores the image data base. The data from scanned images are stored in the TIFF Group IV format and can be retrieved in that format or converted to portable document format (PDF) for viewing through an Applet interface; the conversion to PDF is done, on demand, by a portion of the software that resides on the server. Although the program stores files in the TIFF format, it also supports any other format, and image data stored in any format are retrieved in their native form. Once an image is scanned into the data base, it is immediately available for retrieval. The program includes callable interfaces with other data bases and application programs. It also provides capabilities for administration of the image-storage and -retrieval system.

This work was done by Marie G. Dumoulin, Elias Victor, Sarah A. LeValley, Carolyn F. Paquette, and Susan G. Corbin of **Kennedy Space Center**, *and Thomas P. Duerr and Joseph E. Prevo of Prevo Technologies, Inc.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to KSC-12014, volume and number of this NASA Tech Briefs *issue, and the page number.*

National Instruments, Austin, TX, has introduced three PXI/CompactPCI **vision boards** for high-speed image acquisition from analog and digital cameras. The boards can be incorporated into small, modular computers and automated test systems. The PXI-1407 board acquires images from RS-170 and CCIR monochrome cameras, and features region-of-interest acquisition, which enables users to acquire a portion of the image.

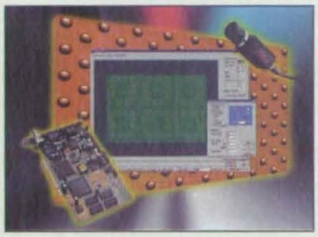
For digital area and line scan cameras, the PXI-1422 boards feature 16 MB of memory, and can buffer large images and acquire high-resolution images at rates up to 80 MB/s from color and gray-scale cameras. One version of the PXI-1422 is compatible with RS-422; the other is compatible with the low-voltage differential signaling (LVDS) specification. Both the 1407 and 1422 feature external triggering, and come with driver software for configuration with camera equipment.

For More Information Circle No. 735

The CV-500 Series **machine vision system** from Keyence Corp. of America, Woodcliff Lake, NJ, features a built-in monitor and controller, and incorporates the Easy Action System (EASY) to shorten set-up time by reducing complex functions to simple commands with pull-down menus. The system includes an integrated one-touch controller and a camera that measure 1.2" square.

Other features include 24.5-million sub-pixel processing; measurement of OD, ID, pitch, and gap; and adjustable target angle compensation to correct for target position variations. Independent processors allow simultaneous use of two cameras, enabling two images to be processed simultaneously. Built-in digital image processing algorithms maintain stable image detection when illumination is reduced.

For More Information Circle No. 736



Cognex Corp., Natick, MA, offers the BGA II **machine vision system** for inspecting ball grid arrays for missing, misplaced, or improperly formed solder balls. The system can inspect up to 10,000 solder balls per second, and offers support for large-format, high-resolution cameras for inspecting smaller sized, densely populated devices. Included is a software package that enables users to add other types of vision functions, such as gauging and surface defect inspection.

The BGA II performs calibration to convert training and measurement parameters from pixels to physical units, and to correct for camera skew, optical distortion, and scaling. It also features a Windows-based graphical device description editor that enables users to train a variety of BGA, flip chip, and chip scale package device types. The package consists of the machine vision inspection software, a Cognex PCI frame grabber, the Windows-based graphical user interface, on-line documentation, and two calibration plates.

For More Information Circle No. 737

Redlake Imaging, Morgan Hill, CA, has announced the MotionScope® PCI high-speed **video capture PCI card**, which records up to 8,000 images per second, using shutter speeds up to 1/40,000th of a second with resolution up to 480 × 420 × 8-bit pixels per frame. The number of images capable of being stored depends upon the disk space on the PC. The system performs motion analysis in pick-and-place applications.

Manual triggering or optical, acoustic, and other sensors can be used to control the recording sequence. Playback uses a point-and-click interface. The system consists of a proprietary monochrome digital camera head incorporating a solid-state, high-speed shutter, a full-size PCI board, cabling, and the MotionScope software. It requires a 200-MHz Pentium-based PC with at least 64 MB of RAM, a 3-GB hard drive, and Windows NT 4.0.

For More Information Circle No. 738

The GP-MF852PT and GP-MF802 **progressive-scan black and white cameras** from Panasonic Industrial/Medical Group, Secaucus, NJ, offer double-speed scanning, asynchronous frame reset, and electronic shutter trigger features. The GP-MF852PT features 1/60 double-speed progressive scan operation; the GP-MF802 offers full-frame progressive scanning.

The GP-MF852PT features reset scanning time at one line, 60 frame camera functions at double speed, simultaneous-use partial frame reset, asynchronous full-frame shutter, readout inhibit, and asynchronous reset functions. The camera also offers a 2/3" CCD and produces more than 500 lines of horizontal resolution in 5 lux at f1.4. The 1/3" CCD GP-MF802 delivers 480 lines of resolution at 6.5 lux, and a signal-to-noise ratio of more than 56dB.

For More Information Circle No. 739

Eastman Kodak's Motion Analysis Systems Div., San Diego, CA, offers the EktaPro CR Model 2000 high-speed **digital imager**, a self-contained unit designed to provide engineers and scientists with a user-friendly way of recording high-speed images for video playback at variable speeds. It also is used as a data source for computerized motion analysis. The imager enables users to record 24-bit color or 8-bit monochrome images at frame rates up to 2,000 frames per second.

A 512 × 384 sensor captures high-resolution images; electronic shuttering eliminates motion blurring, and an anti-blooming feature prevents image degradation under intense lighting conditions. The imager can be operated with an attached handheld keypad, or remotely from a PC via 100-BaseT Ethernet communications. Digital images can be downloaded onto a PCMCIA hard drive or solid-state memory card, or directly to a PC over Ethernet.

For More Information Circle No. 740

Electronic Components and Systems

Circuit Detects Pyrolysis of Polyimide Insulation on Wires

This circuit can also be modified to prevent further pyrolysis.

Lyndon B. Johnson Space Center, Houston, Texas

An electronic circuit has been designed as a prototype of a device that determines whether critical electrical systems have been compromised because of pyrolysis of polyimide-insulated wires. This circuit can be modified to prevent further pyrolysis and to check for indications of pyrolysis for a wide variety of load resistances and power supplies. Circuits like this one could be beneficial in spacecraft, in military and commercial aircraft, and in the nuclear power industry where polyimide-insulated wires are used.

The device is divided into two main sections: a pyrolysis-detection circuit and a potential-pyrolysis-indication circuit. The heart of the pyrolysis-detection circuit is an instrumentation amplifier that monitors the voltage drop across a shunt resistor as current flows through the resistor to a load resistance. If polyimide-insulated wire in series with the load resistance begins to pyrolyze, the current through the shunt resistor begins to increase. If the current exceeds a preset value (in the present design, 1.50 A, corresponding to a pyrolyzed-polyimide resistance value of approximately 35 Ω), then the instrumentation amplifier puts out a signal with a potential of approximately 1.10 V to the inverting input pin of a comparator. The output potential is set to this level by adjusting a gain resistor while 1.50 A of current is flowing through the shunt resistor. When the comparator (which is configured with a threshold voltage of approximately 850 mV) is triggered, a transistor is turned off, thereby disabling a solid-state relay and interrupting the flow of electrical current to the load and the pyrolyzing wire.

After the pyrolysis event has passed, the circuit then tests the pyrolyzed wires and adjacent wiring to determine whether any wires are hazardous. This involves routing the output from a precise 5-mA current source through the load and the low resistance of the pyrolyzed wire. A potential unsafe pyrolysis condition is detected by use of an operational amplifier configured as a comparator with a trigger threshold voltage that corresponds to a critical pyrolysis resistance of approximately 35 Ω. After the threshold voltage has been reached, a transistor becomes turned on, causing illumination of a light-emitting-diode display to indicate the potential unsafe pyrolysis condition in the wiring under scrutiny.

This work was done by Timothy E. Roth of Allied Signal Technical Service Corp. for **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
MSC-22717

Optically Transparent Patch Antennas

Antennas on transparent films can be bent to conform to curved supports.

John H. Glenn Research Center, Cleveland, Ohio

Optically transparent patch antennas have been invented for use in communication systems at frequencies of the order of a few gigahertz. These antennas can be mounted on windows of buildings and vehicles, on computer video monitors, on solar photovoltaic panels, and on other convenient supports; this is an advantage in situations in which the reuse of such supports for radio communication is dictated by a lack of room for adding separate antenna-supporting structures. Another advantage of the optically transparent patch antennas is that they weigh less than conventional antennas do.

An optically transparent patch antenna can be made from an optically transparent, electrically conductive film deposited on one face of a polyester film or a glass substrate; e.g., AgHT, or equivalent. In the case of a polyester film (see Figure 1), the deposited layer has a surface resistance of 6 to 10 ohms per square. The patch and its feed strip can be formed simply by cutting the coated film in the required pattern.

Typically, the polyester film is 0.0075 in. (0.19 mm) thick and is supported over a ground plane by an intervening nonconductive transparent film 0.0035 in. (0.089 mm) thick. Thus, the total thickness of dielectric material supporting the antenna patch is 0.011 in. (0.28 mm). The purpose of increasing the dielectric thickness by use of the intervening film is to increase the antenna bandwidth. Of course the fabrication of such an antenna on polyester film offers the advantage that the antenna can be bent to conform to a curved support.

Figure 2 presents examples of optically transparent patch antennas on glass substrates. Typically, a glass substrate is about 0.0115 in. (0.292 mm) thick and the deposited conductive film has a surface resistance of about 2.8 ohms per square. Whereas a polyester film must be cut to the required pattern, the conductive film on a glass substrate is patterned by depositing the conductive material through the open areas of a photoresist mask.

In tests, prototype optically transparent patch antennas like those shown in Figures 1 and 2 were found to exhibit radiation patterns, return losses, and input impedances similar to those of conventional patch antennas made from copper conductors. The observed radiation patterns are considered to be good for wireless communications, and

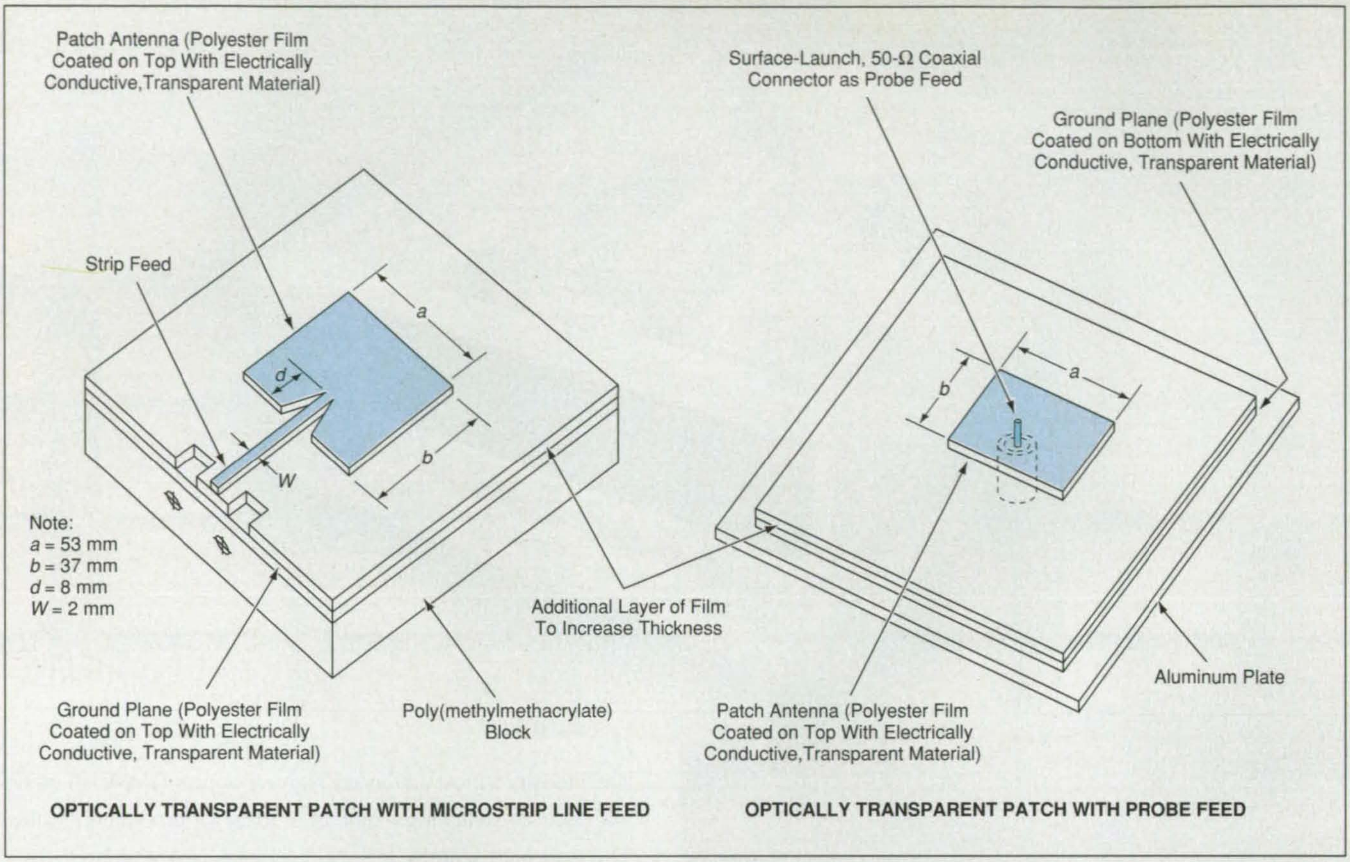


Figure 1. **Coated Polyester Films Cut to Required Patterns** can be used to construct optically transparent patch antennas. These are only two examples of the unlimited number of antenna configurations. The poly(methylmethacrylate) block and aluminum plate in these examples are used for mechanical support only; in a typical application, the support would be a window or other transparent object.

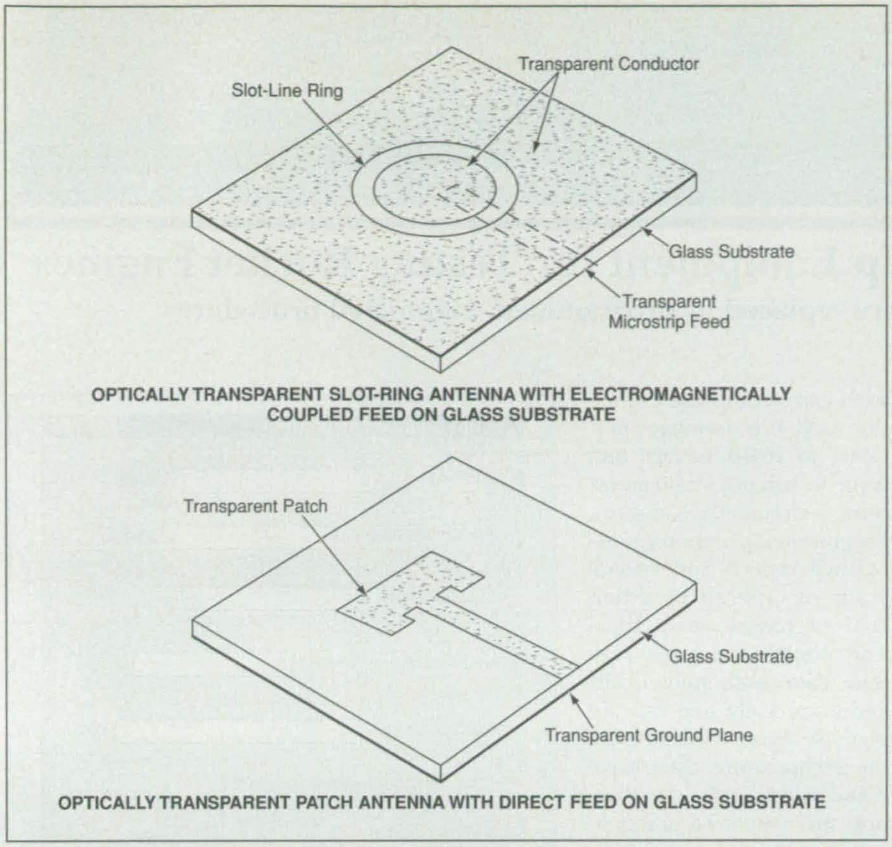


Figure 2. **Conductive Transparent Films on Glass Substrates** can be deposited through photoresist masks in patterns required for antenna patches.

the input impedances are well matched to the practical and commonly sought value of 50 ohms.

This work was done by Richard Q. Lee of **Glenn Research Center** *and Rainee N. Simons of NYMA, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16574.

Wireless Information Network

John F. Kennedy Space Center, Florida

A wireless information network (WIN) is undergoing development for use by workers at locations scattered across Kennedy Space Center (KSC). This WIN could be a prototype of a larger network that would serve all of NASA; by logical extension, it could also be a prototype of commercial WINs. By use of a combination of commercial hardware and custom software, this WIN would give KSC personnel access to the main KSC information systems, electronic mail, and other productivity-enhancing computational capabilities. The software includes the IPSWITCH application program, which is compatible with the Windows 3.1, 95, and NT operating systems. IPSWITCH enables the user to store several network-configuration profiles for a computer work station, making it possible to reconfigure the computer rapidly to operate on different subnetworks. When the user starts the execution of IPSWITCH under Windows, the program generates an interactive display, through which the user can create, edit, and save five different Internet Protocol (IP) configurations for each subnetwork interface.

This work was done by Mark Sullivan for **Kennedy Space Center**. *For more information please contact Kevin Jackson at Sentel Corporation, 225 Reinekers Lane, Suite 500, Alexandria, VA 22314, tel. no. (703) 739-0084 or e-mail kjackson@sentel.com*

KSC-11964

Software for Setting Up Equipment for Testing Rocket Engines

Tedious manual test procedures are replaced by programmed, automated procedures.

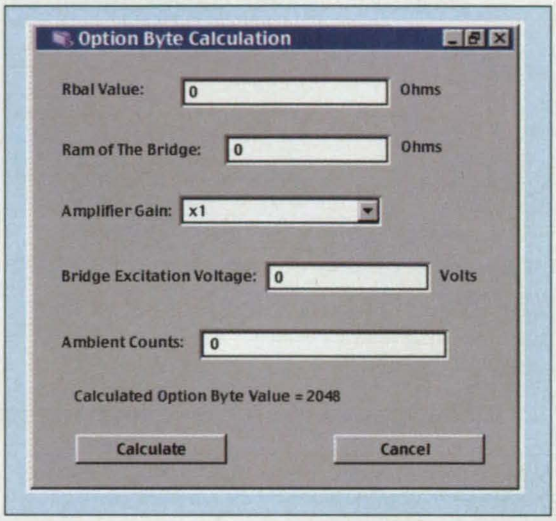
Stennis Space Center, Mississippi

A computer program has been developed to shorten the time needed to set up electronic instrumentation for a hot-fire test of a rocket engine. The instrumentation in question is a modular, partly computer-controlled apparatus, the modules of which contain amplifiers and other signal-conditioning circuits. The apparatus processes signals from strain gauges and other sensors.

Before this program was developed, the modules could be set up only through a controller front panel. Signals from external sources were introduced by unpatching input terminals and applying the signals to amplifiers. The strain-gauge modules are programmed digitally by use of bytes called "option bytes." Before the program was developed, the values of option bytes needed to balance strain-gauge bridge-circuit readouts were found by trial and error. In the case of a thermocouple signal conditioner, it was necessary to disconnect cables to read the true output voltage. For these and other reasons, the time needed to set up the instrumentation for each test was too long.

The program can be used to set up every module needed for a test. Both the amplifier and the remaining signal-conditioning circuitry in each module can be adjusted by use of this software. Each module can be programmed for any desired gain setting and calibration step. It is no longer necessary to resort to trial and error to balance strain-gauge bridge circuits (see figure). Programmable strain-gauge-balance reports and system-status reports can be generated to reduce setup time. The program can display real-time data, both numerically and graphically, and can display the internal memory of the test apparatus; these capabilities can be utilized to diagnose any suspected defect in a measurement or in the entire testing system.

A unique feature of this program is that setup information is sent from the computer that runs the program, via a serial communication port, to a hand-held "dumb" terminal that includes a small display screen and a keypad, which resembles that of a pocket electronic calculator. This feature makes it possible to perform the test setup from either the computer or the dumb terminal. The dumb terminal displays as many as four lines of information from a test-setup-window display on the computer terminal. Each key on the keypad corresponds to a button in the test-setup window. A technician can easily move to and adjust a module while viewing the display on the dumb terminal.



The **Option Byte Calculation** subprogram generates this display. This subprogram calculates the value of the byte needed to balance a bridge circuit in a strain-gauge module.

This work was done by Michael W. Burge of Rocketdyne Division of Rockwell for **Stennis Space Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Transfer Office, Stennis Space Center, Attn: John Bailey (228) 688-1660. Refer to SSC-00093.

Software for Environmental Monitoring in a Large Facility

John F. Kennedy Space Center, Florida

Four computer programs enable the nearly real-time distribution, analysis, and display of data on temperature, relative humidity, and particle fallout measured by sensors in the Orbiter Processing Facility (OPF) and the Launch Pad Payload Changeout Room (PCR) at Kennedy Space Center. The previous environmental-monitoring software distributed data only once per hour; did not provide for rapid, automated analysis; and was not flexible enough to accommodate new sensors. Under the present software, readings are taken from the sensors every 2 minutes and transmitted over local-area networks to a server computer. Any computer on the network can display the data as both numerical values and colors (green, yellow, or red for within, almost out of, or out of specification, respectively). Out-of-specification data is also signaled by audible beeps. Optionally, daily graphs of data can be displayed. The programs, written with LabVIEW software, are modular and can be modified easily to accommodate new sensors, change the sampling interval, enable or disable audible alarms, or rescale graphs.

This work was done by Paul Berry and Chuck Harnden of United Space Alliance for **Kennedy Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-12008.

Sputter Deposition of Catalysts for Fuel-Cell Electrodes

Sputtering offers advantages over other deposition techniques.

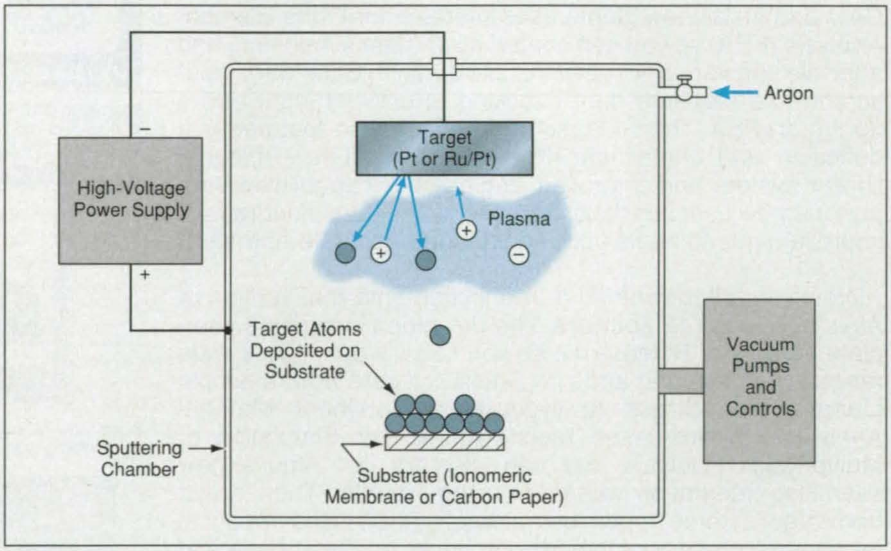
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of fabricating electrodes for fuel cells includes the use of sputtering to deposit thin layers of catalytic electrode metals. Previously, catalytic electrode metals were deposited by means of inks and decals — means that are not amenable to mass production. The sputtering process used in the improved method is better suited to mass production. Sputtering also increases the efficiency of utilization and thereby decreases the needed amounts of the catalytic electrode metals, which are expensive noble metals; whereas the catalyst loadings needed in electrodes made by older methods ranged between 4 and 12 mg/cm^2, the catalyst loadings needed in electrodes made by the improved method range from 0.5 to 1.0 mg/cm^2.

The improved method has been demonstrated in the fabrication of membrane/electrode assemblies for direct methanol fuel cells. Such a membrane/electrode assembly includes a proton-conducting solid-electrolyte membrane sandwiched between two electrode layers. The membrane is made of the ionomer Nafion™ (or equivalent) — a perfluorosulfonic acid-based hydrophilic, proton-conducting polymer. The electrode layers are made of carbon paper coated with catalytic noble metals; Pt for the cathode and an alloy of Ru/Pt for the anode.

Fabrication according to the improved method begins with air drying of the ionomeric membrane for 24 hours, followed by vacuum drying for 30 to 60 minutes. The membrane is mounted in a sputtering chamber, with one side facing up or down toward a target made of one of the noble-metal electrode materials (see figure). The chamber is evacuated, then backfilled with argon to a pressure between 10 and 50 millitorr (between 1.3 and 6.7 Pa). The sputtering process is initiated by applying a high voltage between the target and the chamber wall. The sputtering process is continued for an amount of time (typically ranging up to a few hours) that depends on the desired catalyst loading. Upon completion of sputtering, air is readmitted to the chamber and the membrane is removed.

The foregoing process is repeated to coat the other side of the membrane with the other noble-metal electrode material. Then using sheets of carbon paper (instead of the ionomeric membrane) as the deposition substrate, the process is again repeated, except that Pt is sputtered into both sides of one sheet of carbon paper, and Pt/Ru is sputtered onto both sides of the other sheet of carbon paper. Both sputter-coated carbon papers are coated with a solution that contains the ionomer in a liquid form. Then the membrane is sandwiched between the coated carbon papers and the sandwich is pressed at a temperature between 140 and 150 °C to obtain a membrane/electrode assembly.



Sputtering in Argon Plasma is a superior technique for deposition of catalytic electrode metals (Pt and Ru/Pt) on ionomeric and carbon-paper substrates used to make membrane/electrode assemblies for fuel cells.

This work was done by Barbara Jeffries-Nakamura, William Chun, Sekharipuram Narayanan, Ronald Ruiz, and Thomas Valdez of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category. NPO-20250*

Organic/Inorganic Coats for Packaging of Microelectronics

Thin conformal coats are alternatives to heavier, bulkier conventional hermetic packages.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method for protective packaging of multichip modules and related assemblies of microelectronic circuitry involves coating the assemblies with composite organic/inorganic layers only 1 to 2 mils (0.025 to 0.05 mm) thick. The method is suitable for a variety of advanced packages of microelectronic circuitry, including "chip-on-flex" circuitry, "smart" cards, flip-chips, flip-flips (flip-chips assembled onto ball-grid-array substrates), and such

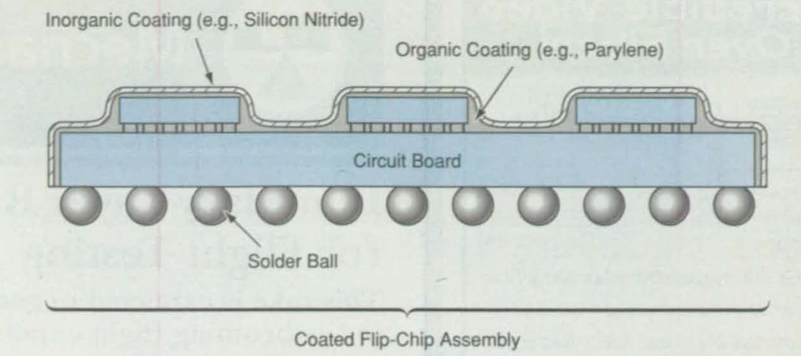
three-dimensional assemblies as stacked memory arrays.

Older methods for protective packaging of electronic circuitry include the following:

- Conventional hermetic sealing in metal or ceramic. This method provides effective protection. However, conventional hermetic enclosures add considerable weight and are relatively bulky [0.15 to 0.25 in. (4 to 6 mm) deep]; thus, conventional hermetic sealing defeats advances in miniaturization.
- Encapsulation in epoxy. Epoxy encapsulants can be applied to depths about one-fourth of those of conventional hermetic packages, but even at these depths, they add unacceptable amounts of weight and bulk. Epoxies are too rigid for use on the new generation of flexible multichip modules. Epoxies are also susceptible to penetration by moisture; in other words, they do not necessarily protect the packaged circuitry against moisture.
- Vapor deposition of a thin film of parylene (a thermoplastic polymer made from para-xylene). Such a film is susceptible to penetration by moisture and to thermal oxidation at temperatures greater than approximately 120 °C.

In the present method, one coats the assembled circuitry with a thin film of parylene, followed by a thin film of silicon oxide or silicon nitride (see figure). Both the organic (parylene) and inorganic (silicon-based) films are deposited at relatively low temperatures (between 25 and 100 °C). The outer inorganic film acts as a barrier to moisture and protects the underlying organic film against oxidation at temperatures up to 200 °C or even somewhat higher. The thin composite organic/inorganic film thus affords almost as much protection as does heavier, bulkier conventional hermetic packaging. The cost of depositing the composite organic/inorganic film is a small fraction of the cost of conventional hermetic packaging.

Although two-layer coats of the type described above are viable, the inorganic outer layers can be broken by mechanical handling. Therefore, it can be desirable to deposit a third (intermediate) layer for protection against mechanical stress (the third layer also provides additional protection against oxidation). For example, one can deposit a base organic layer of Parylene C (a commercial type of parylene), followed by a second organic layer of Cyclotene [or equivalent poly(benzocyclobutene)], followed by an outer inorganic layer.



A **Composite Organic/Inorganic Coating** protects the flip-chip assembly at a fraction of the cost of conventional hermetic packaging.

In the three-layer case described above, one must take special care to cure the second organic layer according to the manufacturer's specifications, to (1) avoid compromising the base organic layer, (2) ensure a full cure to make the second organic layer relatively invulnerable to oxidation, and (3) ensure a smooth, hard second organic layer, over which the final inorganic layer can act as an effective barrier against oxygen. The basic concept can be extended to four or more layers, provided that due consideration is given to adhesion and compatibility between layers. The concept can also be extended to include other materials: For example, other inorganic coating materials that have been considered but not yet evaluated include silicon carbide, silicon oxynitride, and zirconium oxide.

This work was done by Frederick Pool and James Licari of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www. nasatech.com*** *under the Materials category. NPO-20304*

Mechanics

Boundary-Layer Rake of Pitot Tubes for Flight Testing

This rake is expected to generate valuable data in forthcoming flight experiments.

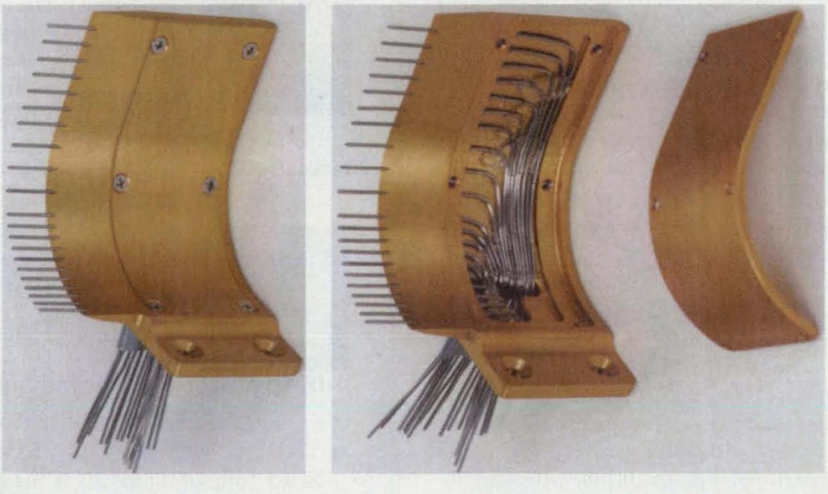
Dryden Flight Research Center, Edwards, California

A boundary-layer rake of pitot tubes has been designed and built for installation on a flight-test fixture (FTF) on the NASA Dryden F-15B, which is a two-seat version of the F-15 high-performance, supersonic, all-weather fighter airplane. This boundary-layer rake will be used in flight-research projects in which there are requirements for detailed surveys of the turbulent boundary layer. A design feature unique to this rake is a curved rake body; this feature makes it possible to cluster the pitot tubes in the near-wall region more densely than they can be clustered in conventional rakes. Results of tests have shown that this rake exhibits good aerodynamic performance and that it is operationally rugged.

To give the rake its complex three-dimensional shape (see Figure 1), it was necessary to resort to innovative solid-modeling and machining techniques. Starting from a three-view conceptual sketch, a three-dimensional solid model was constructed by use of the ProEngineer solid-modeling computer-aided design/computer-aided manufacturing (CAD/CAM) software package. This software package was used throughout the entire design and machining process, ensuring accurate machining of the rake from the three-dimensional solid model. After a solid model was created in ProEngineer, a computer-controlled wire electrical-discharge machine (EDM) was used to cut the basic shape of the rake out of a solid block of aluminum alloy 2024-T351.

The rake was then machined on a computer numerically controlled (CNC) milling machine. First, the base of the rake was machined for flush mounting on a flat surface. To make room for the installation of the pitot tubes, a cavity was machined inside the rake body. Pitot-tube-mounting holes were drilled on the leading edge of the rake, then the leading edge was tapered to a sharp angle. To close off the cavity in the rake body, an aluminum cover was created on the wire EDM.

After the machining process, all parts were deburred, inspected, and then anodized to provide protection from cor-

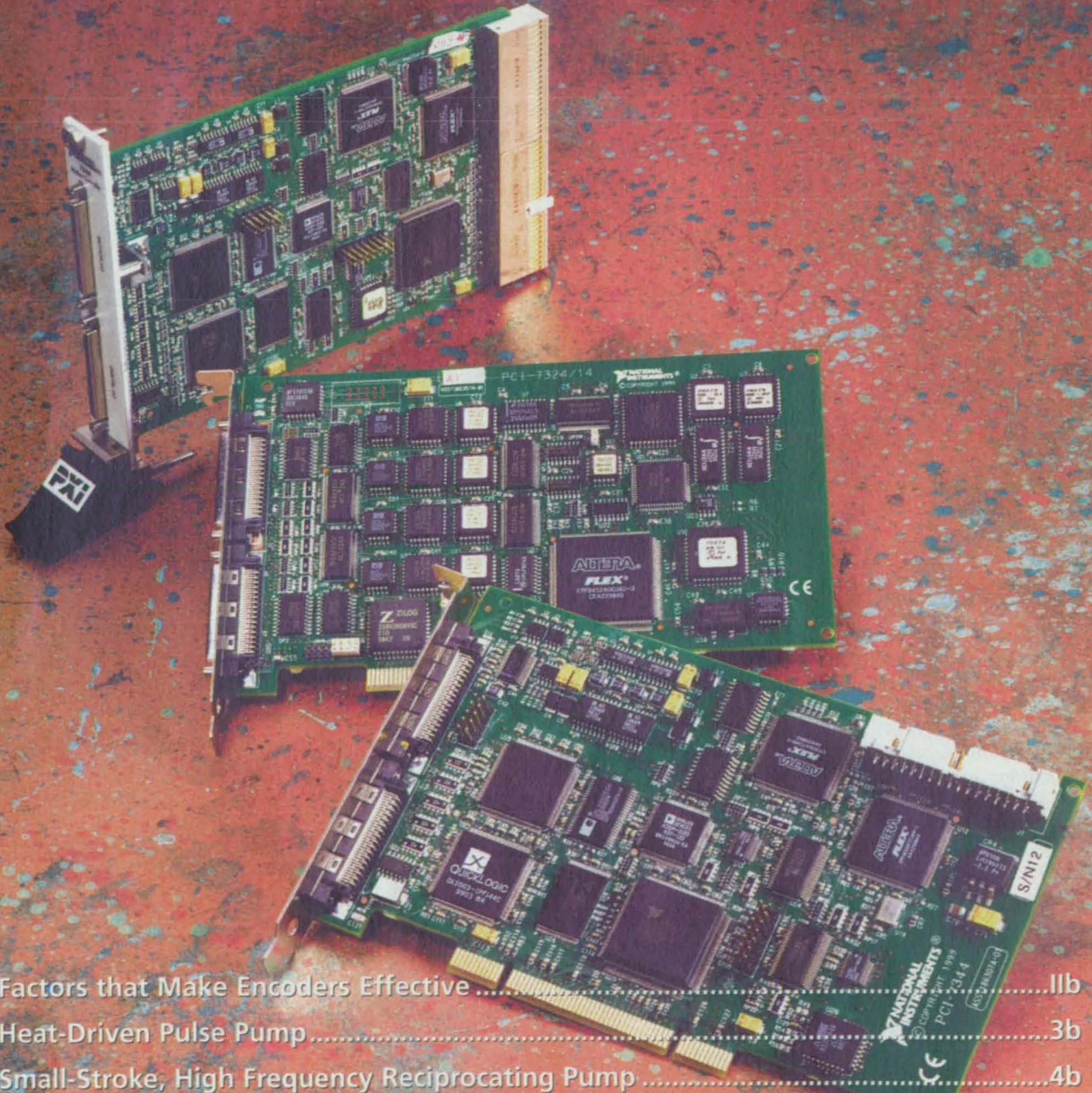


COMPLETE RAKE RAKE WITH COVER OFF

Figure 1. The **Curved Shape** of the boundary-layer rake makes it possible to cluster the pitot tubes more densely in the near-wall region.

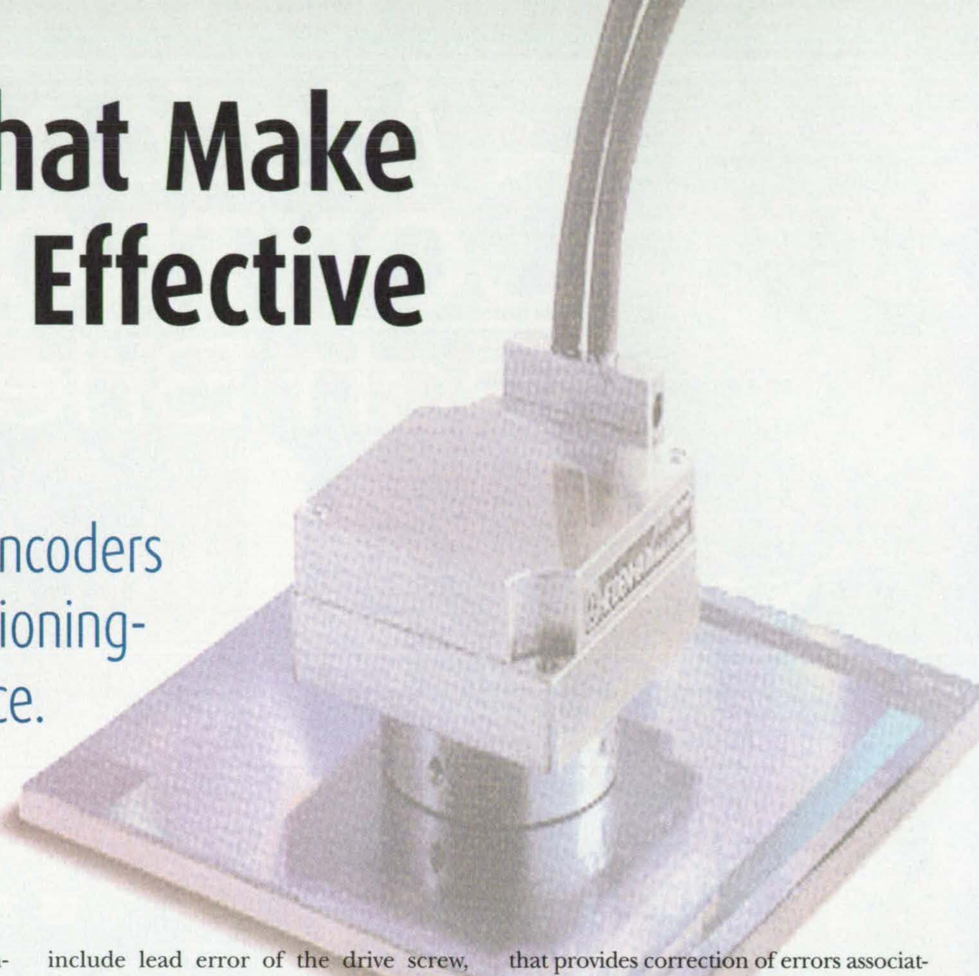
December 1999

Motion Control Tech Briefs



Cover photo courtesy of National Instruments, Inc. See "New Products."

Factors that Make Encoders Effective



If well understood, linear and rotary encoders can augment positioning-system performance.

The need to improve the positioning capabilities of a motion table frequently leads a designer to incorporate measurement transducers, including resolvers and optical encoders, into the system. Such devices, when configured as the master measuring element, afford performance superior to that of the mechanical transmission elements, which double as both the drive and the gauge scale in lower-grade systems. But what is the degree to which such transducers can enhance system performance, and what are the factors that determine their efficacy?

A motion measurement transducer may be coupled either directly to the carriage element of a positioning table, or indirectly through the drive shaft. In the latter case, knowledge of the rotary-to-linear transmission and gear ratios allow for computing the carriage position.

Rotations Considered

Consider a rotary indexing table whose bearing-supported carriage is driven by a worm screw shaft and ring gear transmission, shaft support bearings, and drive-shaft coupling. The positioning error of this mechanism is periodic with respect to the rotations of these elements, and is noncumulative over multiple carriage turns. Positional accuracy of a system whose encoder is coupled through the drive input includes components of uncertainty attributable to each of the drive train elements. These include lead error of the drive screw, thermal expansion of the drive shaft, backlash between engaging components, system hysteresis due to coupling windup, and so forth.

With the transducer coupled directly to the rotating carriage, the uncertainty associated with the transmission is essentially removed from the measurements; the positioning loop is closed at the carriage that provides correction of errors associated with the drive train. The situation is similar in the case of a linear motion system, save for the need of a linear traversing transducer, which is required for direct measurement of carriage displacement. Linear transducers are essential for linear motor and piezoelectric motor-driven positioners, which do not incorporate rotary-to-linear conversion transmissions.

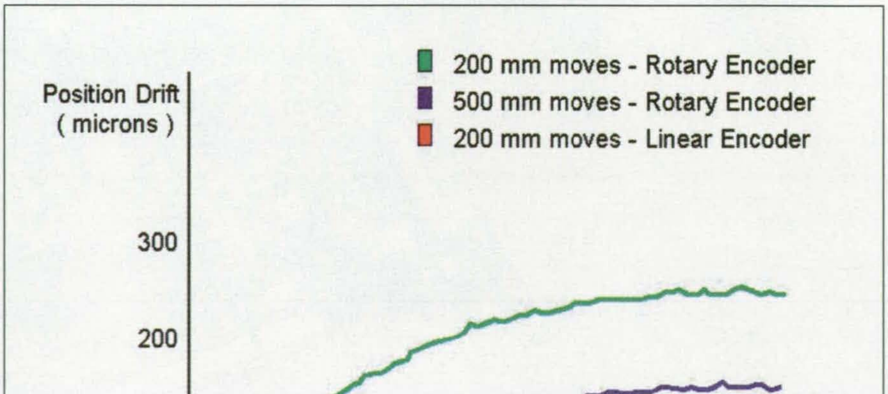


Figure 1. Positional deviations due to drive-screw frictional heating plotted in comparison to the results for the identical single-axis positioner equipped with a linear encoder. Short-move high-frequency motion profiles cause greater heating, which increases position uncertainty. These effects are substantially reduced with linear encoder feedback.

Given the necessary grating precision, the accuracy obtainable with a carriage-coupled rotary encoder is primarily a function of the positional deviation within one complete rotation. The primary source of the error is the radial runout of the bearings that support the encoder. The achievable accuracy is inversely related to the concentricity of the disk with respect to the mechanical rotation axis. In general, attaining rotational accuracy of better than several arcseconds requires concentricity within the range of 1 micron. Installation and alignment of a modular-type rotary encoder (one without its own bearings) to achieve this level of positioning is an exacting task.

Linear System Accuracy

Linear positioning mechanisms exhibit accuracy that is inversely related to their stroke range. A linear motion/rotary encoder system may be compensated for drive-screw thread errors and play between interacting mechanical components. These are, however, variable due to wear, necessitating periodic recalibration. Candidates for particularly frequent readjustment include material cutting systems and any others that involve substantial axial force. Axial stiffness is required to sustain motor input torque and to minimize deformation along with the attendant reversal errors and dynamic inaccuracy.

Consider a hypothetical screw-driven motion table moving a workpiece in a metal-cutting application with the following attributes: The stroke is 600 mm with full-stroke uncertainty of ±50 µm, and the axial stiffness of the table is 120 N/µ. A total moving mass of 250 kg, move profile acceleration of 3 m/sec, and tool forces of 200 N contribute an additional ±7.92 µ of positional uncertainty ascribable to deformation, yielding a total of approximately ±58 µ when measuring inferentially through the drive input.

In rotary encoded linear motion devices, positioning uncertainty is lowered with increased axial stiffness, which is directly related to the preload forces. The cost, however, is higher friction and the resultant heating especially evident in high-duty-cycle operations. Thermal distortion is a major source of mispositioning that must be corrected or compensated for, particularly when the goal is high-accuracy linear movements. Thermal expansion of steel drive-train components occurs at the rate of 4.75 µ/m per °C, with slight variability relative to alloy composition. A temperature rise of 15 °C, if uncompensated, increases position uncertainty by more than 70

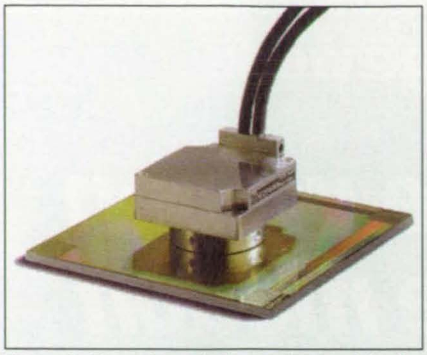


Figure 2. Two-axis optical encoder provides for planar position measurement. (Courtesy of Johannes Heidehain GmbH).

μ in a 1-meter stroke system. Figure 1 compares positioning results for a system using rotary and linear encoding. Drive-screw lead error tends to be cumulative, and the potential improvement in positioning using a linear transducer becomes increasingly advantageous with stroke range.

An enclosed linear scale, in which the grating is premounted in a protective housing, is preferred for material-working/debris-generating operations. Machined attachment pads on the housing lessen the alignment problems at the expense of friction at the interfaces between the reader/seals/scale, which limits the attainable accuracy to the neighborhood of ±3 to 5 microns. With modular transducers, in which there is no physical contact between the scale and the reader, positioning accuracy within the limits of the grating pattern (±1 μ to ±0.1 μ) and the various alignments is achievable.

Geometric Errors

Analogous to the case of rotary measurements, linear positioning performance is related to the alignment between the encoder and the carriage motion axis; here the errors are a function of parallelism with the magnitude of the error the cosine of the misalignment at any given point. Yaw motions (angular movement about the vertical axis of the moving carriage relative to the transducer), roll motions (angular movement about the direction of travel), and pitch motions (movements about the lateral axis that are unrelated to drive-screw thread pitch) give rise to additional components of uncertainty. These "geometric errors" are magnified by any horizontal or vertical offsets between the transducer and the actual "work point" (also known as Abbe error). However the transducer is coupled to the positioner, the degree of precision enhancement that may be realized with such "single-axis sensors" is fundamentally determined by the carriage support and the precise alignment of components in the structure. It is important to note that a single-axis linear encoder cannot compensate for these types of geometric errors.

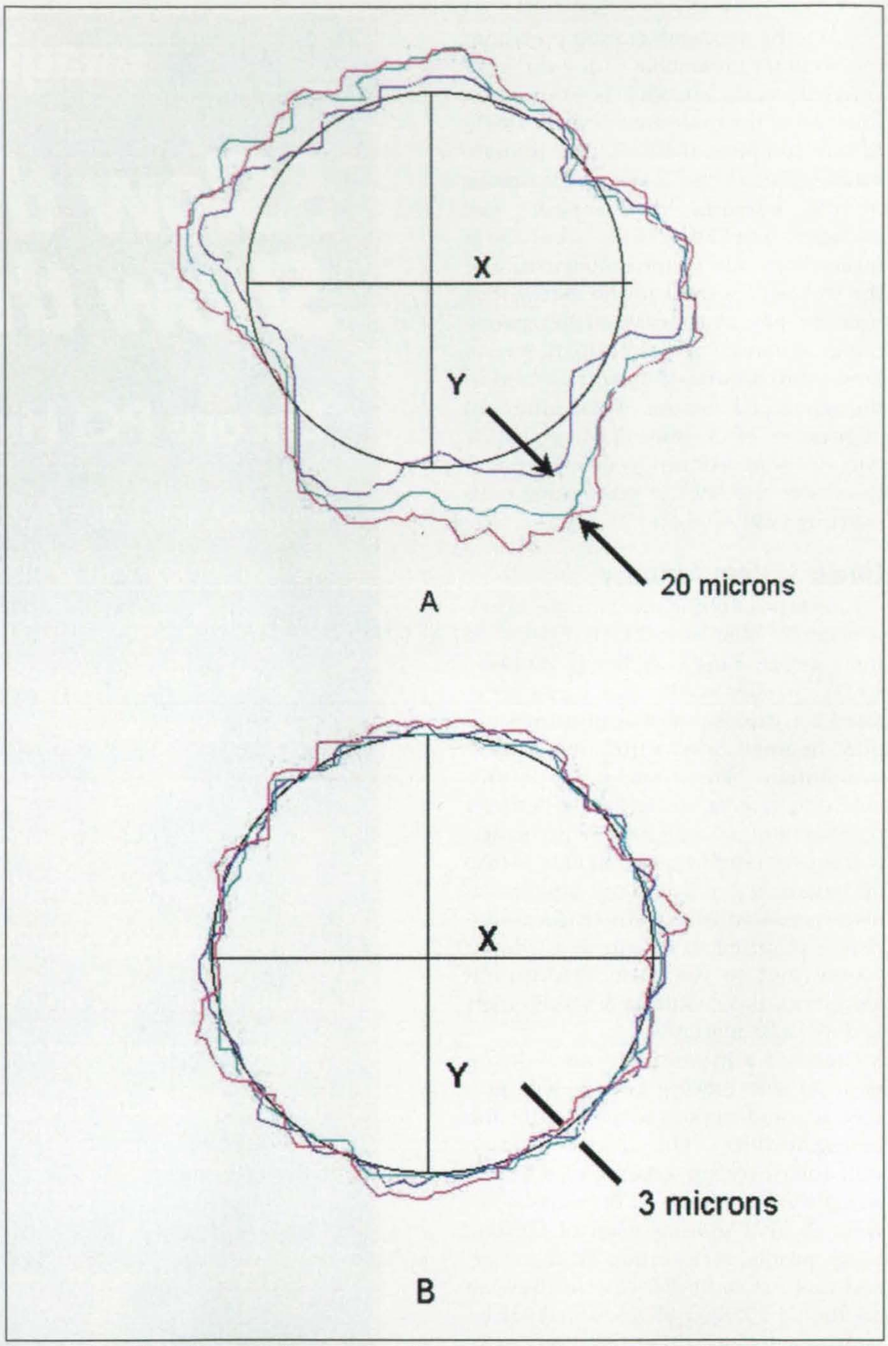


Figure 3. Coordinated two-axis linear motion to generate circular paths with rotary encoders on the drive train (A) and with linear encoders (B). Deviations from the desired ideal path indicate the error components of each linear axis.

Two-axis planar encoders, as shown in Figure 2, provide direct measurement of x-y position over a limited range (approximately 250 × 250 mm). Metrology standards for multiaxis motion (ASME B5.54-1992, section 5.9.3, "Contouring Performance," etc.) are based on the tolerances in repetitively executing circular paths with specified loads and motion profiles, tuning, etc. Circular path quality graphically accounts for the aggregate positional uncertainty in a two-axis system, revealing reversal-error components and geometric errors as shown in Figure 3. Motion-table assemblies with three or more degrees of freedom cannot be corrected for structural/misalignment uncertainties with a positioner-mounted transducer. Attaining spatial accuracy of better than ±5 μ with such complex systems requires laser interferometry, laser Doppler velocimetry, or similar optical beam techniques.

For more information, contact Matt Johnson, Product Manager for the Precision Systems Division of Industrial Devices Corp., 3925 Cypress Drive, Petaluma, CA 94954; 800-747-0064; fax: (707) 789-0175; e-mail: mattj@idcmotion.com; or visit www.idcmotion.com.

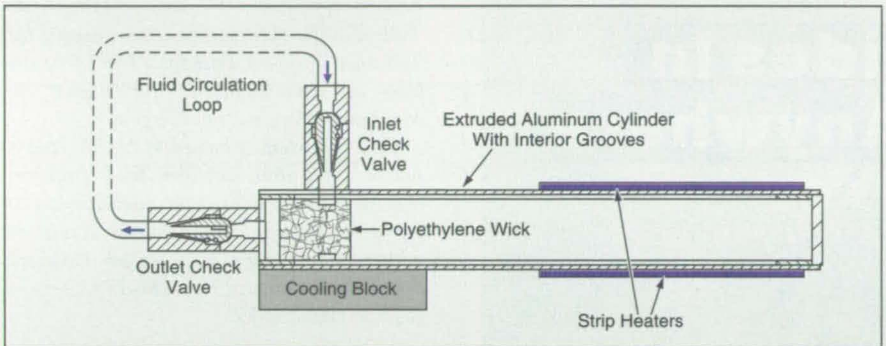
Heat-Driven Pulse Pump

The only moving parts are two check valves.

Goddard Space Flight Center, Greenbelt, Maryland

The heat-driven pulse pump has been invented in an effort to satisfy a need for pumps that can circulate heat-transfer fluids at low flow rates with high reliability over long operational lifetimes. The heat-driven pulse pump (HDPP) is so named because it generates pumping action by exploiting periodic (pulsed) heating and vaporization alternating with cooling and condensation of the fluid to be pumped. To be amenable to pumping by an HDPP, a fluid must, therefore, be one that can be vaporized and condensed within a convenient range of pressure and temperature. Anhydrous ammonia is one example of such a fluid that could be useful in many applications.

A basic HDPP includes a grooved cylinder, a wick, inlet and outlet check valves, strip heaters, and a cooling block (see figure). The cylinder and other parts are sized to suit the specific application. The two check valves are the only moving parts.



In a **Heat-Driven Pulse Pump**, part of the liquid to be pumped is vaporized, thereby forcing part of the remaining liquid through the outlet check valve. During subsequent condensation of the vapor, liquid enters through the inlet valve. The cycle is then repeated.

Initially, the cylinder is filled with the liquid phase of the fluid to be pumped. At the beginning of the pumping cycle, power is supplied to the strip heaters for a specified interval of time (pulse). During this interval, some of the liquid in the cylinder vaporizes. The resulting expansion causes the pressure in the cylinder to rise and the outlet check valve to open. Once the pressure rises to the point where it overcomes the pressure drop in the fluid circuit, the pressure forces some of the liquid through the wick and the outlet check valve; meanwhile, the liquid in the grooves is wicked toward the heater strips and sustains vaporization until the heating power is turned off.

When the heating power is turned off, the vaporization stops. The cooling block is used, if needed, to ensure that during this part of the pumping cycle, the temperature in the cylinder falls to somewhat below the saturation temperature of the fluid-circulation loop. This decrease in temperature causes some or all of the vapor in the cylinder to

condense, and the concomitant contraction and decrease in pressure cause the outlet check valve to close and the inlet check valve to open. The vapor is further condensed by the cold liquid that enters through the inlet check valve, so that the wick, grooves, and interior space of the cylinder become refilled with liquid. The system is then ready for the heat pulse that marks the beginning of the next pumping cycle.

A fluid-circulation system can be made to include a pumping subsystem that comprises three HDPPs connected in parallel. To obtain continuous flow in the portion of the fluid-circulation loop external to the pumping subsystem, the three HDPPs are operated in sequence, with two pumps in the recovery (condensation) part of the pumping cycle while the remaining pump is in the pulse (vaporization) part of the cycle.

A prototype system of three HDPPs with anhydrous ammonia as the pumped fluid was tested in experiments. The pressure drop in the fluid-circulation loop was 0.5 psi (3 kPa). A variety of power settings, fluid pressures, timing sequences, and cooling-block temperatures were investigated. The best combination of settings determined in these experiments was a cooling-block temperature of 15 °C, saturation pressure of 28 psia (193 kPa absolute), and heater power of 50 W applied to each pump during 30-second pulses. With these settings, the temperature in each pump varied sinusoidally between 29 and 35 °C, and the flow rate was 14 grams per minute, which would provide 300 W of continuous heat dissipation. This combination of settings did not allow any pump to become fully flooded before heating power was resupplied, so that liquid was pushed out quickly when the heat was turned on. This concept would also be applicable to a microgravity environment.

This work was done by Steve Matthew Benner of **Goddard Space Flight Center** *and Mario Santos Martins of Jackson & Tull. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351.
Refer to GSC-13739.

Small-Stroke, High-Frequency Reciprocating Pump

Without a sliding piston, the pump could be highly reliable.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed reciprocating pump would operate at a small stroke and would contain no sliding parts. The oscillatory motion of a piston in the pump could be provided by a magnetostrictive actuator, for example.

To compensate for its small stroke, the pump would have to operate at a high frequency at which most check valves do not work well and at which the pump would be sensitive to trapped air if its piston area were small. Valve efficiency could be increased by use of flapper valves or nozzles. Effective piston area could be increased, without increasing the diameter of the pump, by use of multiple pistons or a helical piston.

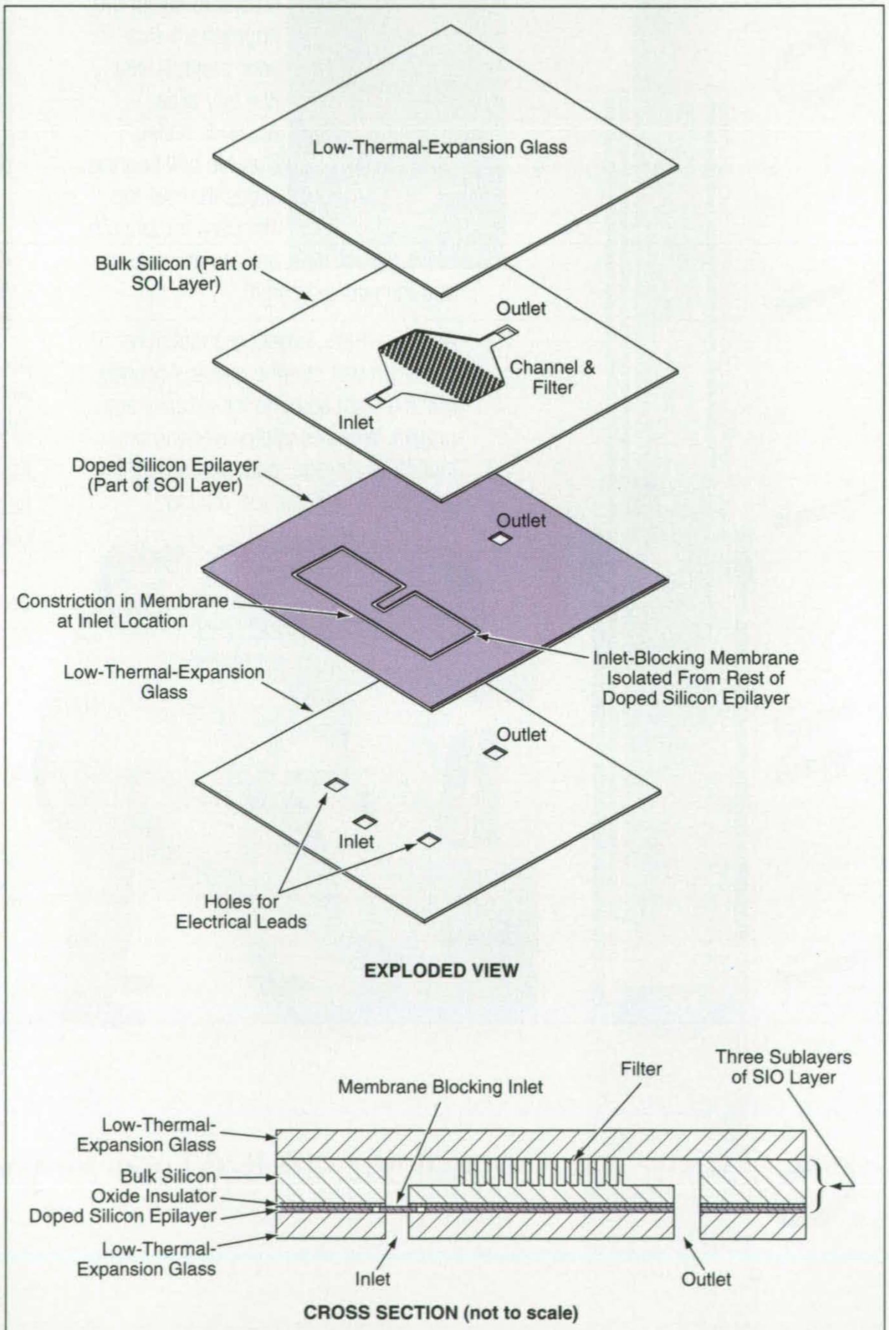
This work was done by Arnon Rieger, Michael J. Gerver, Ralph C. Fenn and Dariusz Bushko of Satcon Technology Corp. for **Johnson Space Center**. *No further documentation is available.*
MSC-22462

Alternative One-Time-Opening Miniature Isolation Valve

Valves like this one could be used in microspacecraft propulsion and chemical analysis.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts a proposed miniature, electrically actuated, one-time-opening isolation valve that would be made mostly of silicon, by use of micromachining techniques. Isolation valves are needed in systems in which fluids must be stored for long times until use, with no leakage or contamination prior to release. Miniature isolation valves like this one could serve to control the release of propellant liquids or gases in microspacecraft, or of stored chemical reagents in portable *in situ* chemical-analysis apparatuses. Eventually, such



The **Doped Silicon Membrane Blocking the Channel** would be melted electrically to open the channel. According to the concept reported in the noted prior article, a channel would be blocked by a silicon plug doped through part of its thickness. Unlike the plug, the membrane in this design would be likely to melt completely.

apparatuses may include one-time-use biochemical-analysis chips.

The proposed valve would function similarly to the one de-scribed in "One-Time-Opening Miniature Isolation Valves" (NPO-19927), *NASA Tech Briefs*, Vol. 21, No. 2 (February 1997), page 4b. However, the design and thus the details of the micromachining process would differ. Like the previously reported valve, the proposed valve would contain a flow channel blocked by an electrically conductive barrier made of doped silicon. Metal electrical leads would connect the barrier with a valve-opening electrical circuit. To open the valve, the circuit would supply enough electrical current to melt the barrier. The pressurized up-stream fluid released by melting of the barrier would carry the barrier debris downstream. A filter downstream of the barrier site but upstream of the outlet would capture the debris.

The overall dimensions of the valve would be about 10 by 10 by 2 mm. The valve would comprise three layers that would be micromachined individually, then assembled and bonded. The middle layer would be a silicon-on-insulator (SOI) wafer that would comprise three sublayers: an upper bulk silicon sublayer several hundred microns thick, a middle oxide insulating sublayer a few microns thick, and a lower doped silicon epilayer some tens of microns thick. The SOI wafer would be micromachined from both sides to create an inlet sealed by an epilayer membrane, an outlet, a channel between the inlet and the outlet, and a filter in the channel. The top layer — a wafer of low-thermal-expansion glass — would be anodically bonded to the top surface of the SOI wafer to seal the channel. The bottom layer would be another low-thermal-expansion glass layer containing micromachined openings for the inlet, outlet, and two electrical leads. The bottom glass layer would be anodically bonded to the bottom surface of the SOI layer.

The SOI layer would be the most complicated part of the valve; micromachining of the SOI layer would involve several steps. By means of a patterned etch of the bottom surface of the SOI layer, the portion of the doped silicon epilayer in the outlet region would be removed, while a strip of the doped silicon epilayer in the inlet region would be isolated to form the membrane covering the inlet and extending between electrical contacts. (This membrane would constitute the barrier to be melted by electrical heating. A constriction in the membrane at the inlet location would ensure concentration of electrical heating in the portion of the membrane blocking the flow channel.) Then by means of a patterned etch from the top surface of the SOI layer, holes for the inlet, outlet, and electrical leads would be formed through the thickness of the bulk silicon sublayer. The channel between the inlet and outlet, containing an integral filter, would be formed in still another patterned etch.

This work was done by Indrani Chakraborty, Juergen Mueller, Andrew Wallace, and Wen Li of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20473

Axial Force as Indication of Alignment of Threaded Fasteners

A robot would imitate a human technician feeling a thread-engagement click.

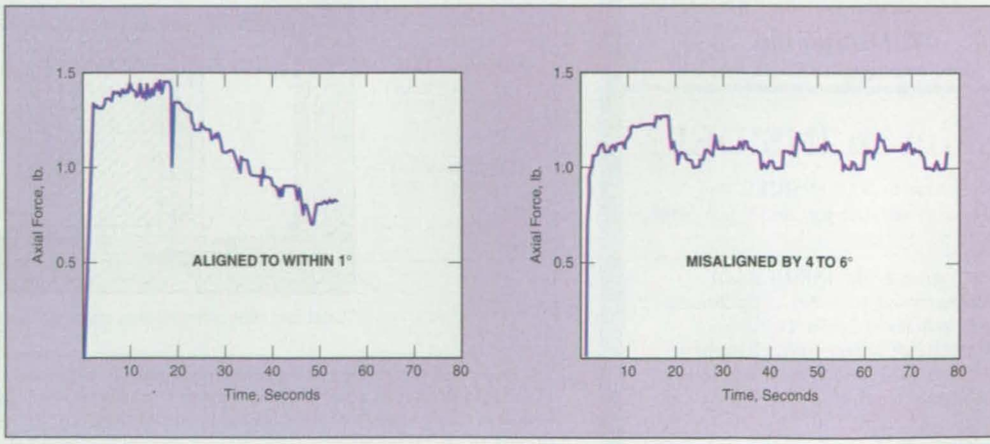
Lyndon B. Johnson Space Center, Houston, Texas

A developmental technique for automated alignment of threaded fasteners involves the use of the axial force between the fasteners as an indication of alignment. The technique was conceived as a means to guide a robot that is required, for example, to join a bolt with a nut.

The technique is based on the well-known fact that when a bolt and nut are properly aligned, gently pushed together along their common axis, and turned in the loosening direction (counterclockwise for conventional right-handed threads), there is a click — that is, a brief relaxation and recovery of axial force — once per rotation, each time the ends of the threads slip past each other. The technique is also based on the conjecture that the magnitude of the click decreases as the angle of misalignment between the bolt and nut increases.

In a typical application, the robot hand would hold the bolt or nut and would bring it into contact and approximate alignment with its mating nut or bolt, respectively. The robot hand would apply a small preload contact force. Then by actuation of the robot hand or by another mechanism cooperating with the robot, the bolt and nut would be rotated, relative to each other, in the loosening direction. During the rotation, strain gauges in the robot hand would measure contact forces that could be resolved into the axial contact force between the bolt and nut. The axial-force signal would be processed by the robot control system to determine the degree of bolt/nut misalignment (if any) and thus to determine any needed corrections to the position and orientation of the robot hand.

In experiments to test this concept, a robot hand held a 1/2-in. (12.7-mm)-diameter bolt against a nut that was rotated counterclockwise with a period of about 18 seconds. The left part of the figure shows an example of the axial force versus time in an experiment in which the angle between the bolt and nut axes was ≤1°. The initial rise in force of 1.3 lb



Axial Force between a bolt and a rotating nut was measured by a robot hand that held the bolt.

(≈5.8 N) was caused by a command from the robot control system to press the bolt into the nut with this amount of force. (This level of preload was essential for reducing the effect of strain-gauge noise.) At approximately 5 seconds, the counterclockwise motion started. At approximately 21 seconds, there was a 0.5-lb (2.2-N) dip in axial force (a click), indicative of proper alignment of the nut and bolt threads. At this point, the robot control system sensed the change in the axial force and the rate of change of axial force, and responded by generating a command to reverse the rotation in order to tighten the bolt and nut. Thereafter, the axial force decreased as the engagement of the nut and bolt relieved some of the preload.

The right part of the figure depicts the axial force versus time in an experiment that was similar except that the angle between the bolt and nut axes was between 4 and 6° (close to the cross-threading angle for the particular bolt and nut). The initial rise in the axial force was similar to the one described above, but the subsequent clicks were smaller. The force and the rate of change of force did not change sufficiently for the robot control system to recognize "good" alignment; therefore, the system did not command a reversal of rotation from counterclockwise to clockwise. However, the axial-force signal included a periodic feature that indicated the instant when the threads could mate if they had been better aligned. In principle, the robot control system could be modified to recognize this feature and to command the fingers of the robot hand to tilt the bolt as a function of an axial-force gradient until alignment was obtained.

This work was done by Myron A. Diftler and Michael L. Ross of Lockheed Martin for **Johnson Space Center.**
MSC-22837

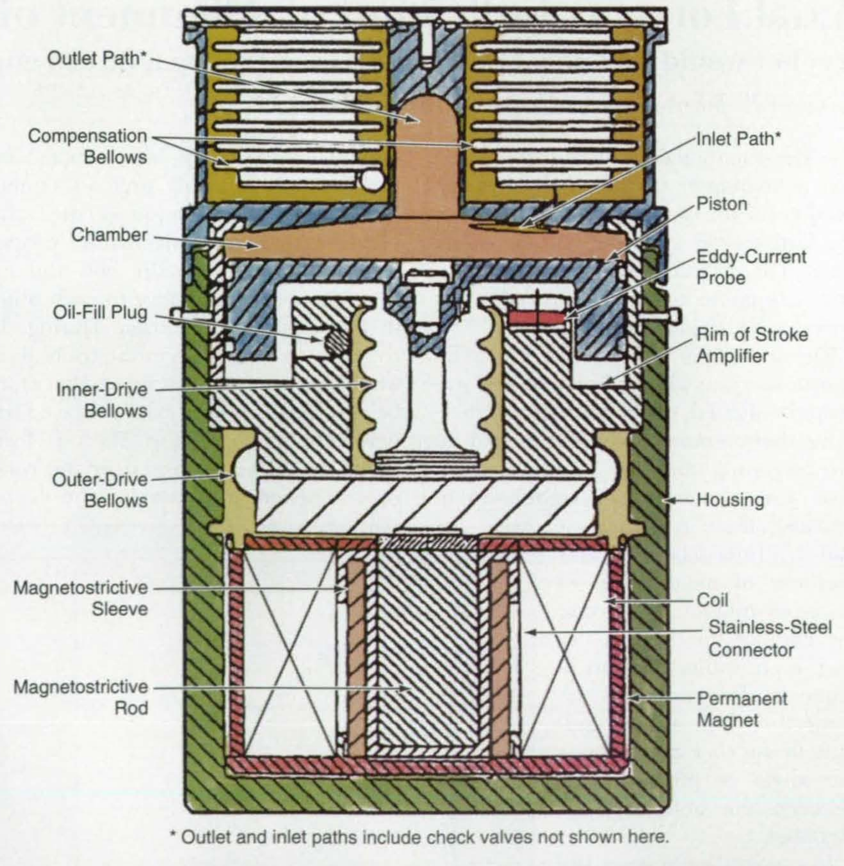
Improved Magnetostrictive Pump

Features include a two-stage magnetostrictive actuator and a hydraulic stroke multiplier.

Lyndon B. Johnson Space Center, Houston, Texas

An improved magnetostrictively actuated pump has been developed to satisfy a need for a small, low-pressure, high-flow-rate fluid pump that contains few moving parts and can run reliably for long periods without maintenance. The pump could be used, for example, to circulate water in the portable life-support system worn by a firefighter or a chemical worker or in any setting where reliability is important and maintenance is difficult. The pump is designed primarily for water as the pumped fluid, but it could also be used with other fluids, including cryogenic ones.

The figure shows a meridional cross-section of the pump. The bottom part



* Outlet and inlet paths include check valves not shown here.

The **Improved Magnetostrictive Pump** is designed to take maximum advantage of the small stroke of the magnetostrictive actuator. Because this stroke is so small, great care must be exercised in design and assembly to optimize the bias stress on the magnetostrictive components, and to maximize the rigidity of all components except for the required degrees of compliance of the bellows and the springs (not shown here) in the check valves.

contains a magnetostrictive actuator, including an annular permanent magnet that provides a constant (bias) magnetic field, and an electromagnet coil that generates the variable magnetic field needed for actuation. The magnetostrictive material is the alloy $Tb_{0.27}Dy_{0.73}Fe_2$ (commercially available under the trade name "Terfenol-D").

The unusual aspect of the actuator lies in a two-stage design that approximately halves the actuator length needed to obtain a given stroke. There are two pieces of magnetostrictive material, each 1.5 in. (3.81 cm) long: a central rod 0.75 in. (1.9 cm) in diameter, and a surrounding sleeve of the same volume as that of the rod. The upper end of the sleeve pushes against the lower end of the rod via a stainless-steel connector, so that the rod telescopes out from the sleeve and the magnetostrictive strain of the rod is added to that of the sleeve to obtain nearly the same total strain as that of a 3-in. (7.6-cm)-long, 0.75-in. (1.9-cm)-diameter rod of the magnetostrictive material. The connector is designed to undergo very little strain, relative to the magnetostrictive strain at the anticipated actuation loads.

The diameter of the two-stage actuator is greater than it would be with a single stage, but this increase in diameter does not increase the overall diameter of the pump, because the piston that effects the pumping action has a greater diameter. In addition, power consumed by the two-stage actuator is only slightly greater than it would be for an equally capable single-stage actuator.

Above the actuator is a hydraulic stroke amplifier that includes an outer and an inner drive bellows. This stroke amplifier multiplies the actuator stroke by about a factor of 7.5 [from 2 to 15 mils (0.05 to 0.38 mm)] while dividing the actuator force by a factor of 10 in driving the piston. About 75 percent of the work done by the actuator goes into the output of the stroke amplifier; the remaining 25 percent is consumed in compression of the hydraulic fluid and strain energy of the bellows.

The stroke amplifier drives the piston, the periodic motion of which draws water into a chamber through an intake valve and pushes the water out of the chamber through an outflow valve. These are lightweight, fast-response, spring-positioned check valves. These valves are positioned to make the water flow circumferentially around the chamber to obtain a centrifugal effect that makes trapped air bubbles accumulate at the center of the chamber, where they flow out. The accumulated air must be vented because the pump stroke is so small that even as little as a few milliliters of trapped air greatly impedes performance, and more than that amount can totally block the pumping action.

Above the pump chamber in which the piston operates there are two compensation bellows — one on the intake side and one on the outflow side. These bellows smooth out the flow, reducing the pulsations that occur at the pump operating frequency, which is about 24 Hz. If the pulsations were not smoothed out, they would give rise to huge forces (water hammer) that would build up in the water tubes connected to the pump and thereby prevent the pump from operating.

The pump is designed to have a flow rate of 30 milliliters per second and a pressure of 5 psi, and to consume about 25 W of electric power.

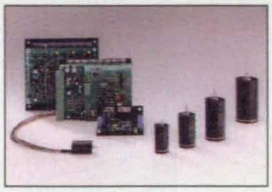
This work was done by Michael J. Gerver, Robert Ilmonen, Frank Nimblett, and John Swenbeck of SatCon Technology Corp. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery and Automation category.*
MSC-22890

New Products

Absolute Encoders with DeviceNet™

The new Models A25 and A58 added to the Dynapar line by Danaher Controls, Gurnee, IL, feature a built-in DeviceNet™ field-bus interface, which the company says makes installation and troubleshooting significantly easier than other encoders in current use. Integrating the interface into these encoders also eliminates the need for third-party PLC cards, additional I/O, and hard-wiring to a PLC, plus PLC code development to automate the systems. Danaher says that providing a constant position signal and automatic referencing of position upon startup or after power loss increases data integrity and repeatability.

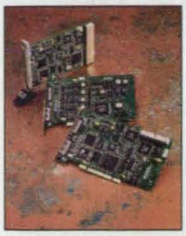
For More Information Circle No. 765



Autoclavable Brushless Motors

Micro Mo Electronics, Clearwater, FL, announces what it calls the first full line of autoclavable motors for medical and extreme operating environments. Based on System Faulhaber® ironless rotor technology, the new design combines no-cogging, high-acceleration dynamics with powerful rare-earth magnet systems, according to the company. Sterilization parameter test for the series is at 134 °C ±2 °C, with a water-vapor pressure of 2.1 bars. The line can operate in 100-percent relative humidity in 20-minute cycles for a minimum of 100 cycles. In case diameters of 16, 20, 24, 30, and 35 mm, the standard versions are available in 12 VDC and 24 VDC.

For More Information Circle No. 766



Motion Controller Boards

National Instruments, Austin, TX, adds three new motion controller boards to its product line. The PCI-7344 and PXI™-7344 modules control both servo and stepper motor applications for PCI, CompactPCI, and PXI systems. The PCI-7324 closed-loop board controls stepper motor applications for PCI systems. The 7344 controllers are dual-processor devices that directly control motors with industry-standard command signals, amplifier inhibit/enable signals, and forward, reverse, or home-limit inputs for each axis. The PCI-7324 stepper board controls up to four stepper motors with fully programmable pulse and direction or clockwise/counter-clockwise output signals.

For More Information Circle No. 767

Control for Hydraulic Proportional Valves

A new solenoid-mounted controller/amplifier from HydraForce Inc., Lincolnshire, IL, uses high-frequency pulse width modulation switching to supply a hydraulic proportional valve with a proportional input signal. The external signal can be from a potentiometer, 0-5 V DC, or 0-20 mA source. The device mounts directly to solenoids having DIN 43650 connectors, and is rated to IP65 standards for weather resistance. The controller will accept any power supply voltage from 9-28 VDC. Ramp and dither signals are independently adjustable; I-min and I-max settings are independent and non-following.

For More Information Circle No. 768

Three Adjustable-Frequency Drives

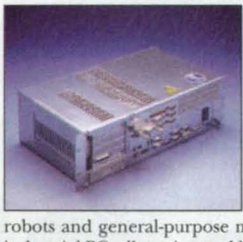
Danfoss Electronic Drives, Rockford, IL, introduces the VLT® Micro, 2800 series, and 5000 series, three new adjustable-frequency drives. VLT Micro are low-cost drives offering 1/2 to 2 HP, and are suitable for OEMs and panel builders requiring small AC motor control. VLT 2800 series drives are available from 1/2 to 5 HP and offer side-by-side, horizontal, or vertical mounting capability. VLT 5000 series drives incorporate a sensorless vector drive system for variable speed and torque control of AC induction motors from 1-600 HP. VLT 5000 series drives react to system load changes within 3 milliseconds.

For More Information Circle No. 769

DSP-Based Servo Drives

The Epsilon Series servo drives from Emerson Motion Control, Chanhassen, MN, operate direct on-line at 42 to 264 V AC, and are available in two power ratings: 1.8 A and 3.0 A rms current with 2× peak. These are the smallest DSP-based servos available from Emerson, fitting into a 6-in.-deep enclosure with cables connected. The motors deliver 5 to 15.8 lb.-in. at up to 5000 rpm. Five flexible modes of operation are available: analog velocity, analog torque, pulse follower, digital velocity preset, and summation of analog velocity and digital velocity. Standard features include 8 optically isolated I/O.

For More Information Circle No. 770



Motion and Logic Control System

Bosch Automation Technology, Racine, WI, introduces the Rho4, a PC-based motion and logic control system for robots and general-purpose machines. Built into an industrial PC, all motion and logic is processed on an Intel Pentium-class microprocessor that also runs the operator interface. Interface screens are written in standard Visual C++ or VisualBasic programming tools, with application communication through standard DLLs, DDE, or OLE protocols. The Rho4's features include 24 axes, 16 kinematics, BAPS+ flowchart motion programming, and an "open motion" interface to drives.

For More Information Circle No. 771

Precision Dovetail Slides

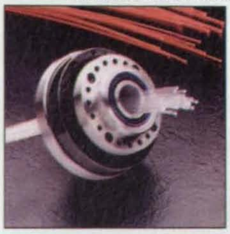
The Setco Group, Master Division, Cincinnati, OH, offers the Master DS series of dovetail slides in three models: Express, Select, and Super Select. The Express slides, engineered for applications requiring compact design and quick shipment, are available in 4-, 6-, 8-, 10-, or 12-in. base widths. Select slides expand the choice of drive styles, accessories and sizes, offering base and saddle lengths in one-inch increments up to 64 in. Super Select slides, designed around a standard baseline platform, can meet virtually any requirement in size and capability, allowing Master's engineers to create custom slides without long lead times.

For More Information Circle No. 772

Motion Controller with Modbus

Galil Motion Control, Mountain View, CA, has added support of the Modbus Ethernet protocol and multi-master and multi-slave capabilities to the DMC-2100 standalone controller. Modbus, a serial bus developed by Modicon that enables communication between I/O devices, is seen by the industry as the standard protocol for distributed control systems, according to Galil. The DMC-2100's multi-master capability enables multiple computers to talk directly to the controller using Ethernet, and the multi-slave capability of the DMC-2100 is in direct communication to all I/O devices via the Ethernet local area network.

For More Information Circle No. 773



Miniature Hollow-Shaft Housed Unit

HD Systems, Hauppauge, NY, introduces the SHF-14-2UH, a new miniature zero-backlash harmonic drive speed reducer with a large hollow shaft. The units measure only 53 mm long and 74 mm in diameter, yet have a hollow shaft inside diameter of 14 mm. The large through-hole allows the engineer to pass shafts, wire bundles, or other components directly through the gearing's center. Rated output torques of 69 in.-lb. and momentary peak torques of 478 in.-lb. can be achieved, HD Systems says, because of the company's patented "S" tooth profile. Gear reduction ratios of 50:1 through 100:1 are available in a single stage.

For More Information Circle No. 774

Brush-Commutated/Brushless DC Gearmotors

The LO-COG® brush-commutated DC gearmotors from Pittman, Harleysville, PA, utilize spur gearheads and can deliver up to 500 oz.-in. of torque at the output shaft. They are available in three frame sizes with several length and performance options. ELCOM® and ELCOM II slotless brushless DC gearmotors are equipped with planetary gearheads, and are also available in three frame sizes with a range of lengths and performance options. Pittman says their slotless construction reduces inductance, improving current bandwidth for responsive control and superior acceleration.

For More Information Circle No. 775

Rotational Speed Monitor

Turck Inc., Plymouth, MN, announces the *multi-modul*® MK21-RI, which it calls the industry's first rotational speed monitor with intrinsically safe inputs with both relay and analog outputs. It is designed to monitor pulse sequences from NAMUR sensors in hazardous locations, convert the pulse input into a 4-to-20-mA rotational speed output, and indicate overspeed and underspeed conditions to control equipment in non-hazardous locations. The device can detect rotational speed from 1 mHz to 10 kHz. An LCD display indicates actual speed, measured in user-defined units.

For More Information Circle No. 776

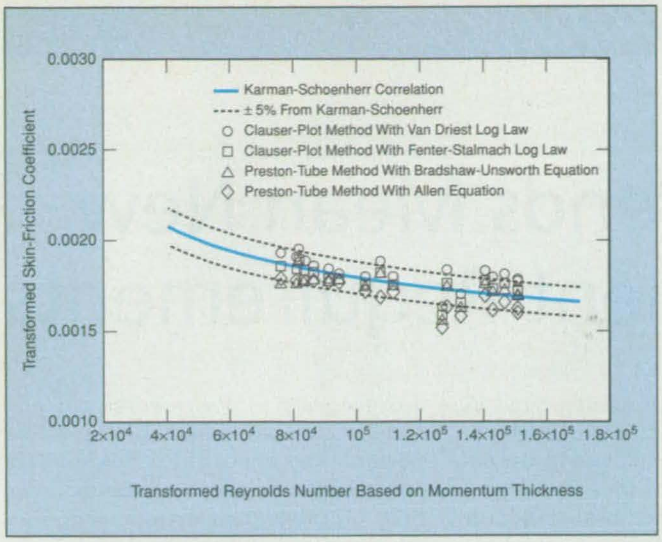


Figure 2. These **Flat-Plate Skin-Friction Data** were calculated from measurements taken by the boundary-layer rake shown in Figure 1.

rosion and wear. The pitot tubes were machined from 304 stainless steel tubing of 0.04-in. (1.0-mm) outside diameter and 0.0075-in. (0.19-mm) wall thickness that had been annealed to a 1/2-hard condition. The pitot tubes were then inserted in the rake body. The tips of the pitot tubes were chamfered to reduce their sensitivity to local flow angles. A low-viscosity, single-component, anaerobic methacrylate ester adhesive (Loctite 609) was used to hold the pitot tubes in place. To help keep the pitot tubes in place and to protect them from vibrations during flight, room-temperature-vulcanizing (RTV) silicone rubber was used to pot the inside of the rake cavity.

A finite-element stress analysis of the rake design showed very high factors of safety for operation in a supersonic wind tunnel. The rake passed a ground vibration test in which random vibrations of 12 times normal Earth gravitational acceleration were imposed for twenty minutes along each of the three mutually perpendicular directions. A wind-tunnel test of the rake was conducted in the NASA Glenn Research Center 8-by-6-ft (2.4-by-1.8-m) supersonic wind tunnel at mach numbers ranging from 0 to 2. The rake pitot pressures agreed well with data obtained from a conventional rake for the entire range of mach numbers tested. The boundary-layer profiles obtained from the rake data matched the standard log-law profile. As shown in Figure 2, values of skin friction computed from the rake data by use of the Clauser-plot method agreed well with Preston-tube results and with the Van Driest II compressible skin-friction correlation.

The rake will be used in a number of future F-15B/FTF flight experiments. One experiment currently underway is an in-flight evaluation of new skin-friction gauge concepts: the rake data as well as the results from a Preston tube will be used to evaluate the accuracy of new skin-friction gauges. Another experiment is planned to validate the microblowing drag-reduction technique in flight: In this experiment, the net drag reduction caused by blowing an extremely small amount of air through a porous plate will be calculated from the momentum balance of the boundary-layer profiles measured by the rake in the upstream and downstream regions of the porous surface.

This work was done by Trong T. Bui and David L. Oates of **Dryden Flight Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Dryden Flight Research Center; (805) 258-3720. Refer to DRC-98-94.

Optical System Trends Mean New Test and Measurement Requirements

What is the trend in fiber optics? It is simple to say that there has been an ever-growing need to transmit data at ever-higher data rates. Regardless of the application — commercial or military, land or sea, air or space — people want to move more data and move it faster than ever before. In response, single-wavelength, singlemode telephony systems have given way to higher throughput, dense wavelength-division multiplexed (DWDM) broadband systems. The once moderate data rates of multimode LANs, campus backbones, and avionics links have given way to new systems with Gigabit throughput.

Enhanced system performance has spawned both the development of new components (i.e., DWDM filters) as well as the higher performance grades of existing components (i.e., fiber, splitters, couplers, and optical amplifiers). The increased complexity and performance demands of these new high-throughput systems have meant more complex testing and performance verification on both the direct component level as well as the finished link. As a result, fiber optic test and measurement equipment has been forced to further evolve to meet these advanced measurement needs.

Evolving Acceptance Testing Requirements

The early 1970s saw the deployment of the first optical communication systems based on multimode fiber and light-emitting diode (LED) sources. By the mid-1980s, a significant evolutionary shift occurred as telephony and broadband applications made the switch to singlemode fiber. This switch was fueled by the availability of singlemode-compatible laser transmitters, which offered the higher modulation rates (1 GHz+) and higher output powers (up to several 100mW) needed to support interoffice trucks and long-haul telephony links.

Multimode technology did not sit still. Continued evolution in component and production technology finally brought multimode fiber to the critical point of cost parity versus copper. Multimode fiber took to the LAN battleground as fiber-based implementations of Ethernet (10 Mb/s) took root, followed by the development of the Fiber Data Distributed Interface (FDDI) network standard. FDDI became the industry standard for campus backbone and private networks until about 1990.

The pressure for increased bandwidth, along with the development of cost-effective multimode laser transmitter technology, has brought multimode to the Gigabit plateau. Over the last few years, 10 Mb/s Ethernet has given way to Gigabit Ethernet (GbE), using its high-speed pipeline to enhance system performance in applications like campus backbones and switch-to-switch/switch-to-server applications. FibreChannel has evolved to Gigabit FibreChannel (GFC), and OC-3 (150 Mb/s). Asynchronous Transfer Mode (ATM) technology has given way to higher speed OC-12 (500 Mb/s) and OC-24 (1 Gb/s) products. In a quest for higher performance at lower costs, expensive 1300-nm multimode laser technology has been supplanted by 850-nm Vertical Cavity Surface Emitting Laser (VCSEL) technology offered in low-cost, integrated transceiver packages. In time, the need for longer link lengths will drive VCSEL technology to the lower-loss 1300-nm operating window.

The shift to laser sources brings the need for characterizing and controlling back-reflections (also called return loss), never a prior concern with low-coherent LED sources. Back-reflections are present in all fiber optic systems, both singlemode and multimode. However, components used in multimode systems tend to cause higher reflections, and generate lower return loss values, in part due to the greater physical dimensions of the connector interfaces and higher backscatter level of the fiber.

The commercial data communications sector is just learning that control and verification of the optical connectors' polished endface is no longer just a requirement for singlemode connectors. Controllling radius of curvature, apex offset, fiber height, and APC angle are necessary to assure consistent performance among randomly mated connectors. Also important is how endface control directly affects connector reliability over time, temperature, and other environmental influences.

New military and aerospace network standards are observing the lessons learned from the commercial telecommunications sector and recognize the need to characterize all performance variables for both reasons of system performance and mission critical reliability. Insertion loss, return loss, and connector endface geometry comprise the critical elements under review.

Thus, higher standards of performance and requirements for more comprehensive and complex acceptance testing have emerged. Unlike the simple loss-only test requirements of the early FDDI era, commercial Gigabit has established a longer list of required tests to be applied on both the component and system levels.

Previous Gigabit test requirements meant insertion loss for connectors, span loss for fibers, and end-to-end link loss for the overall link. The new MM Gigabit test requirements mean insertion loss, return loss, and endface geometry for connectors; span loss for fibers; and end-to-end link loss and optical return loss (ORL) for the overall link.

Singlemode Systems: New Test Requirements

Traditionally, singlemode fiber has been the domain of the high date rates combined with long distances (up to several 100 km with optical amplifiers). These single-carrier systems require simplified optical layer testing as follows:

- Connectors: Insertion loss, return loss, and endface geometry
- Fibers: Span loss, chromatic dispersion, polarization dependent loss (PDL), and polarization modal dispersion (PMD)
- Multiplexers and Demultiplexers: Insertion loss, return loss, polarization dependence
- Transmitter: Output power and long-term stability

• Receivers: Receiver sensitivity, input power range, signal degradation, and loss of signal threshold
• Overall Link: End-to-end link loss and Optical Return Loss (ORL)

The Internet has led to an insatiable demand for bandwidth in the telecommunications transport network. The existing network can no longer support demand, leading to fiber exhaustion in many high-traffic locations where optical transmission systems operate at only one wavelength. Consequently, service providers have begun deploying dense wavelength division multiplexing (DWDM) systems along with higher speed SONET transport networks to solve these fiber exhaust situations. DWDM allows several wavelengths of light in the 1550-nm low-loss wavelength window to be multiplexed onto a single fiber, thereby increasing its capacity. For example, 16 channels of OC-48 data equals a total throughput of 40 Gb/s. In the not so distant future, we can expect to see DWDM systems with up to 196 channels operating at even higher OC-768 (10 Gb/s) rates, which equals the incredible throughput of nearly 2 Terabits/sec (Tb/s).

DWDM deployment has dramatically increased the complexity of these measurements by adding the wavelength dependence factor. Unlike its single-wavelength brethren, DWDM optical layer testing incorporates an expanded array of tests, including:

• Connectors: Insertion loss, return loss, and endface geometry
• Fiber: Span loss, chromatic dispersion, PDL, PMD
• Dispersion Compensating Devices: Insertion loss, PDL, delay ripple, and loss ripple versus bandwidth
• Transmitters: Wavelength accuracy, spectral width, output power, long-term output stability, side mode suppression, and extinction ratios
• Receivers: Receiver sensitivity, input power range, signal degradation, and loss of signal threshold
• Dense Multiplexers and Demultiplexers: Central wavelength, bandwidth, insertion loss, and ripple of each individual passband; channel differential loss or device ripple; and PDL versus wavelength
• Optical Amplifiers: Gain versus wavelength, spectral gain flatness, gain equalization, optical signal-to-noise ratio (OSNR), amplifier noise figure/gain ripple/tilt versus bandwidth and varying gain levels, optical return loss (ORL)
• Optical Add/Drop Multiplexers (OADM): Passband insertion loss and ripple, channel isolation, ORL, and PDL
• Overall Link: End-to-end link loss, Optical Return Loss (ORL), and PMD

DWDM components require a very complex set of performance measurements. Today's DWDM system measurements are performed by essentially single-function, laboratory-style test equipment carried out to the field, and run on AC power. Consequently, the commercial roll-out of DWDM transmission systems is forcing the development of new generations of optical test sets that need to be fully portable to support efficient field operation. The evolving multi-function DWDM test set must also strive to integrate a full range of measurement capabilities, including:

• Optical spectrum analyzer (OSA)
• Wavelength meter
• Chromatic dispersion meter
• PDL and PMD test set
• Optical return loss (ORL) meter
• Optical insertion loss (OIL) meter

For more information, contact the author of this article, Dennis Horwitz, Vice President, Mil-Aero Division, RIFOCS Corporation, 1340 Flynn Rd., Camarillo, CA 93012; Tel: 805-389-9868; Fax: 805-389-9808; www.rifocs.com.

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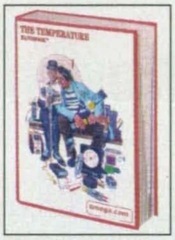

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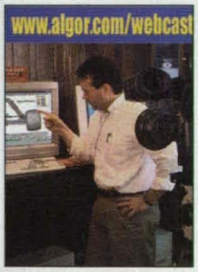

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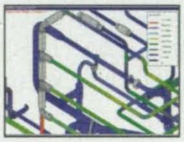

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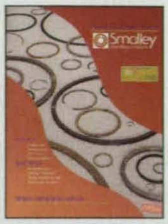

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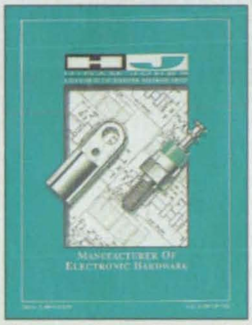

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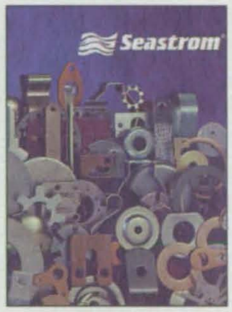

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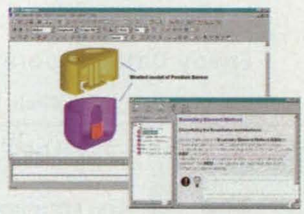

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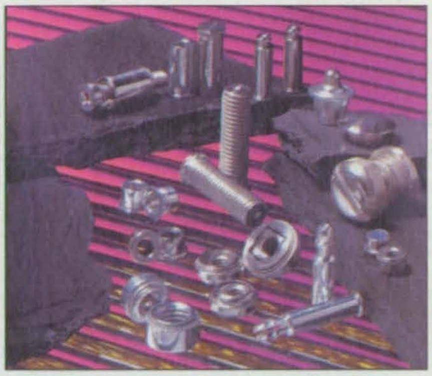

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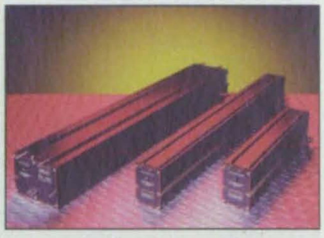
Headquartered north of Seattle in Mukilteo, Washington, Synrad operates on a simple philosophy — to design and manufacture a range of high-technology products that are easy to use, reliable, and affordable, thereby opening up new applications for sealed CO_2 laser technology worldwide.

Synrad lasers, when combined with suitable optical assemblies, motion systems, and computer controllers, have countless manufacturing applications, and new applications continue to be discovered daily. These lasers are ideal in applications involving drilling, cutting, and marking



on steel, plastic, wood, paper, fabric, and other organic materials.

Available with output powers from 10 to 240 watts, Synrad lasers feature the patented "all-metal" tube design, which ensures a high laser gas purity, and therefore an exceptionally long operating lifetime. In fact, a Synrad laser can be expected to perform continuously for more than 35,000 hours with no maintenance requirements. The durable metal tube enables these lasers to withstand harsh industrial environments, and because the tube can be simply and inexpensively produced, a Synrad laser is very affordable.

For more information on laser technology and Synrad's sealed CO_2 lasers, contact a sales engineer at 1-800-SYNRAD-1, or visit Synrad on the World Wide Web at www.synrad.com.

Circle No. 654

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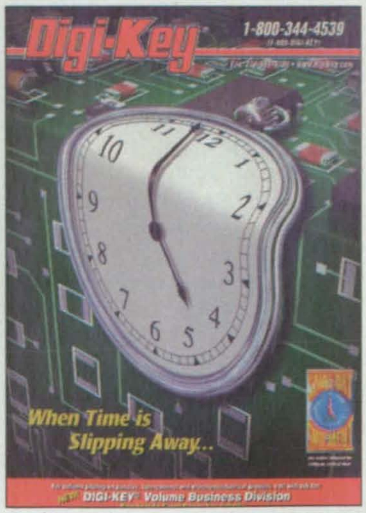

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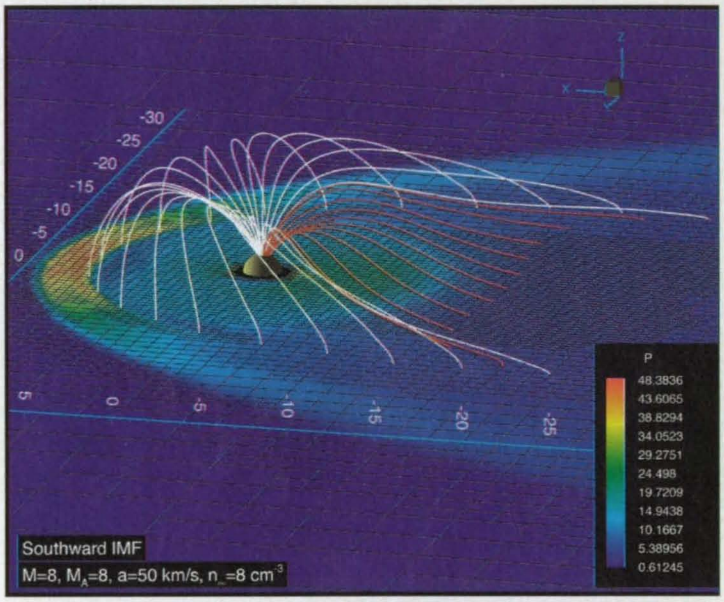

For more information, contact Amtec Engineering, Inc., 13820 SE Eastgate Way, Ste. 220, Bellevue, WA 98009-3633; Tel: 1.800. 763.7043 or 425.653.1200; e-mail: info@amtec.com, www.amtec.com

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Keithley offers a broad line of fully integrated products for testing portable telecommunications devices such as cellular phones, pagers, mobile radio base stations, and digital switch systems used in product design, production, and QA/ QC labs.

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STAHL SPECIALTY COMPANY

Stahl Specialty Company is a leader in the aluminum foundry industry and has been making casting from the tilt-pour permanent mold process since 1946. Applications such as automotive, agricultural, heavy truck, marine, and food service are some of the markets served. Stahl has been making parts for the automotive industry since 1978. One area of application for automobiles that Stahl has expertise in is suspension parts such as control arms. Stahl has supplied control arms to the automobile industry since 1993.

The main reason for converting suspension parts to aluminum from other materials such as iron castings and steel stampings is weight savings. This translates into lower vehicle weight and better fuel economy. One important side benefit discovered after the implementation of aluminum control arms was an improvement in unsprung weight of each wheel, which refers to the amount of mass of each wheel that is available to be "thrown around" as the vehicle encounters road imperfections such as bumps and potholes. Additionally, aluminum control arms dampen the impact better than steel stamped control arms, resulting in less vibration transmitted through the car.

Aluminum control arms are fairly new to the automotive industry, but they are becoming more widespread each model year as the confidence level increases in their ability to perform in many different vehicle applications. Superior mechanical properties and casting soundness are a must for the aluminum control arm to be successful. A sound casting, combined with a custom tailored heat treat, will yield a casting with exceptional mechanical properties.

For more information, contact Stahl Specialty Company, 111 East Pacific, PO Box 6, Kingsville, MO 64061-0006; Tel: 800-821-7852; Fax: 816-597-3485; www.stahlspecialty.com

Circle No. 659

♦ALGOR®

Drop Test Analysis Performed with MES Software Determines Limits of ELF Oil Rig Protection Net

This artist's rendering shows the main oil platform and two satellite drilling rigs currently under development in the North Sea. (Inset shows construction site in Scotland.) Pipelines on the ocean floor will transport oil to the main platform via oil-carrying risers within the platform legs. The oil will be processed and then carried ashore via separate export lines. ALGOR's Mechanical Event Simulation software was used to determine the limits of protection nets, which will be positioned at the top of two legs to prevent objects from falling into the leg trusses and damaging oil-carrying risers.

Advances in computer-aided engineering technology are enabling engineers of all disciplines to create more complex, detailed finite element models that realistically simulate the behavior of interacting systems. Recently, engineers at Selantic Industrier A.S. in Agotnes, Norway used Accupak/VE Mechanical Event Simulation (MES) software from Pittsburgh-based ALGOR, Inc. to simulate a steel container impacting a dropped object protection net—a virtual prototype test that previously could only be performed physically in a laboratory.

Selantic engineers were asked by Technip-Geoproduction of France (Technip) and McDermott of the UK in partnership with ELF Exploration UK PLC to develop a new protection net for a "jack-up" oilrig. This type of platform is constructed onshore as one complete unit and then towed into position at sea where its legs are lowered. On contact with the seabed, its deck is jacked-up above sea level.

The ELF platform is currently under development in the North Sea off of the East Coast of the UK. A protection net will be situated within the trusses of two of the platform's three triangular-shaped legs. Each net will be attached to a circular steel ring positioned just above the leg.

Loading cranes located directly above the legs will transport shipping containers carrying supplies between the platform and ships daily. The protection net will prevent falling containers from damaging oil-carrying risers, which are mounted inside the legs and transport oil from the ocean floor. The engineers needed to restrict the net's maximum deflections to protect the risers while ensuring the net will withstand stresses created upon impact by a container.

The MES Approach

Lars Bjoland, technical manager of Selantic Industrier and an ALGOR customer for over seven years, is no stranger to ALGOR's finite element analysis (FEA) software; however, the protection net project was his first attempt at using ALGOR's Accupak/VE MES capabilities.

"In the beginning of the project, my colleague performed some rough hand calculations to determine the best approach for the net design," Bjoland said. "We could not make any solid conclusions from his work because it was too vague. Performing the calculation manually would be impossible."

The next logical step was to turn to FEA. Bjoland originally modeled the net using Superdraw III, ALGOR's precision finite element modeling tool, and replaced the falling object with nodal forces acting directly on the net. Bjoland was unsatisfied with this for two reasons: calculating the correct loading was complicated and time consuming and replicating the real-world behavior of the net impacted by a container was impossible.

Modeling the container and applying known physical properties such as its dimensions, mass and the height from which the container falls enabled Bjoland to realistically simulate the interaction of the container and the net within a short time frame.

To set up the MES, Bjoland added a container model to the existing protection net model. The net model was made of truss elements with three degrees of freedom. A rope would exhibit resistance only when pulled outward like a cable when the object strikes the net; thus, Bjoland did not consider bending moments.

Bjoland positioned the 5,000-kg steel container model, measuring 2 by 2 m, approximately 12.6 m above the net. The net had three sides, each 16-m long, and was terminated in each of the three corners with fully constrained boundary conditions. He specified gravity for the container. Bjoland designated contact elements between the container surfaces and the net to enable complete interaction, including the transfer of inertia from one object to the other.

Then Bjoland specified the duration of the MES because he wanted to simulate the system's behavior over time. After specifying material properties of steel for the

container and of aramid, a synthetic fiber, for the ropes, Bjoland processed the nonlinear elastic material model with Accupak/VE.

Analysis Results and Modifications

According to Bjoland, the initial deflections exceeded Technip's failure criteria of 2.6 m, the distance to oil-carrying risers beneath the net. Bjoland performed several variations of the analysis, dropping the container at the center, at one corner and along the edge of the net, to confirm the results.

"After the first set of analyses, we were able to determine that the current net design would fail under the extreme loading from the impact," Bjoland said. "Without Accupak/VE, we would have been required to make a prototype to get the same conclusion."

Technip revised the requirements and asked Bjoland to perform a modified set of analyses. The new net design included ropes made of a high-performance fiber HMPE (High Molecular Polyethylene), a lightweight fiber material that is stronger and exhibits the best elasticity and breaking strength. In addition, the new design called for nine termination points at the corners and along the edges compared to the previous design's three points. Three of the points will be adjustable in order to pre-tension the net.

The modified set of analyses revealed much more reasonable deflections throughout the net and satisfactory material dimensions. Stresses at the termination points were higher, but within acceptable limits, according to Bjoland. In addition, the MES showed that the net would stretch permanently under maximum loading. This was not a concern because a net will be replaced after each drop incident. To present the results to his client, Bjoland created *.avi* files from the MES using ALGOR and converted them to VHS video format.

Physical Prototype Testing

Bjoland anticipates conducting small-scale physical prototype tests to confirm the MES. This testing will replace full-scale testing that would have been necessary if he had not used Accupak/VE. This translates into less time and material costs for prototype testing as well as decreased time-to-market.

"Had we not used Accupak/VE, we would have needed to do full-scale testing to find deflection and termination forces," Bjoland said. "We also would have been required to perform additional physical testing to determine the design modifications that we made after the initial Mechanical Event Simulation."

This small-scale physical prototype testing is planned for 1999 with the platform becoming operational in the year 2000. Bjoland expects to use Accupak/VE for future projects. "Engineers always need to be open to new ways of solving problems to get the best results," Bjoland said. "If we hadn't been open to a new method of modeling in this case, we would not have been able to show the behavior of the net as quickly or inexpensively."

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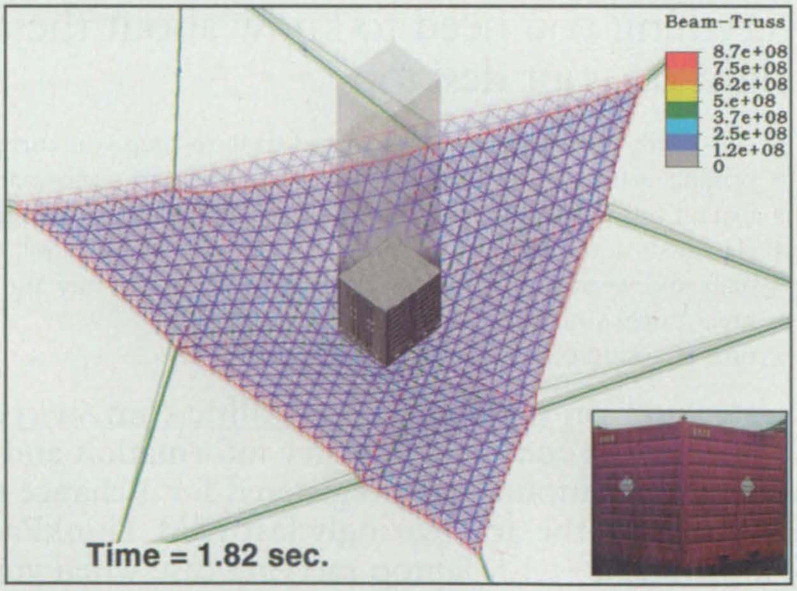
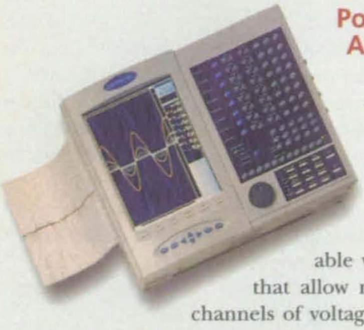


The Mechanical Event Simulation predicted the deflections and stresses caused when a container, such as the one shown in the inset, falls from a height of 12.6 m. The analysis verified that maximum deflections would be under 2.6 m, the distance to critical oil-carrying risers beneath the net. Because virtual prototypes of the net were created using Mechanical Event Simulation, Selantic will not need to conduct full-scale laboratory tests, decreasing the time and cost of physical prototype testing.

New on the MARKET

Portable Data Acquisition



The WR1000 portable data acquisition system from Western Graphtec, Irvine, CA, is designed for high-capacity analysis, display, and logging of both static and dynamic data. It is available with 8, 16, 24, or 32 channels that allow mixing/matching of up to 16 channels of voltage, frequency, bridge, and voltage thermocouple preamps. The system processes data for real-time display, using RAM of 256 (optional 512) Kwords/channel. It also captures data in real time to a built-in 9-GB hard drive or to external storage. The system measures 15 × 13 × 5 inches in its 16-channel version, making it suitable for field, laboratory, and factory-floor applications. **Circle No. 700**

Hermetic Seals

Tekna Seal, Minneapolis, MN, a division of Maxwell Technologies, has announced a line of hermetic headers, connectors, and feed-throughs that feature pins made of alumel, chromel, or copper. These pin materials can be used in glass-to-metal seals with a variety of body materials. Alumel, chromel, and copper pin materials are used in the temperature-sensing industry and other applications requiring low electrical resistance. **Circle No. 702**

Urethane Adhesives

Loctite Corp., Rocky Hill, CT, offers PROFORM™ 3630, 3631, and 3632 reactive urethane hot melt adhesives. The solid, single-component structural adhesives behave like standard hot melts until partially set. By reacting with moisture to crosslink, reactive urethanes form a new polyurethane polymer. Reactive urethanes also are heat and chemical resistant. Applications include automotive assembly and panel assembly. **Circle No. 703**

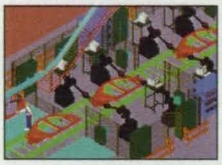
Quick-Release Connectors

Barksdale, Los Angeles, CA, offers a variety of quick-release electrical connectors for their level-switch product line. The Model BLS-7 features internal or external side mounting; non-metallic-welded, no-leak construction; and broad media compatibility. The BLS-700 is custom-built to specifications, meeting customer requirements for mounting, float and stem material, number of switch points, electrical rating, and overall length. **Circle No. 709**

New on DISK

Visual Data Analysis

PV-WAVE 7.0 visual data analysis development software from Visual Numerics, Boulder, CO, combines data analysis, data visualization, and system administration. The software is an open environment for developing and deploying visual data analysis (VDA) applications. PV-WAVE 7.0 features 76 new mathematical and statistical analysis routines from the company's IMSL C Numerical Library, new functionality for array manipulations, and an improved mapping module. Floating licenses can now be shared between Windows and UNIX platforms. **Circle No. 712**



Factory Automation

Engineering Animation, Ames, IA, has announced Open Virtual Factory (OVF) software for visually integrating an enterprise's complete manufacturing process, from initial product design to final production. The program enables users to share visual data, including ergonomics and human factors, factory-layout data, and product and process features. Manufacturers can place virtual humans within simulated factory layouts for ergonomic and safety analysis. **Circle No. 713**

Plastics Part Management

C-MOLD, Louisville, KY, offers C-MOLD KnowHow!, a Web-based environment for creating, managing, and publishing plastics part design and manufacturing engineering data. The software enables collaboration between engineering teams, functioning as a plastics-engineering workgroup portal. Users can add their own content to KnowHow!'s repository of plastics information. It also serves as a front-end to C-MOLD's CAE applications, including Project Engineer, 3D QuickFill, and C-MOLD Advanced Solutions. The program comes with a built-in Web server that facilitates access to and management of information. It can be installed on any Windows NT server or workstation, and is accessed by a standard Web browser. **Circle No. 714**

3D CAD Model Viewer

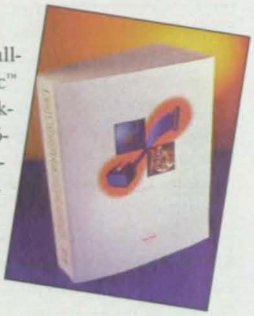
Actify, San Francisco, CA, has announced that its 3D View™ CAD model viewer now supports Parametric Technology Corp.'s Pro/ENGINEER CAD system, allowing users to view and share native Pro/E parts and assemblies without access to a Pro/E workstation. 3D View enables non-CAD professionals to view, measure, and markup native CAD files where no CAD system, server, or transition is required. It allows CAD designers to share 3D models with suppliers, customers, managers, sales, marketing, and other engineers. 3D View also supports CATIA, IDEAS Web Access, SolidWorks, Solid Edge, AutoCAD, Mechanical Desktop, and Parasolid. **Circle No. 715**

Visualization and Analysis

Intelligent Light, Lyndhurst, NJ, offers FieldView 6 analysis and visualization software that provides integration with CFD workflow, enhanced numerical calculations, and presentation rendering features. It also contains a data handling technology called Data Guide™. Other features include numerical export to integrate CFD results with external applications, and floating licenses across mixed UNIX and Windows networks. Advanced lighting, rendering, and color control features also are included. **Circle No. 717**

New LITERATURE

Electronic Connectors

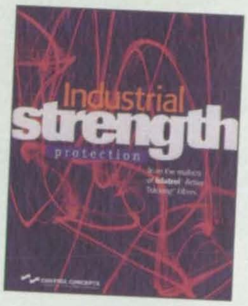


Molex, Lisle, IL, offers a 1,598-page full-line catalog with new listings for HiSpec™ edgecard connectors, RIMM memory sockets, cable products, and PanelMate™ 1.25-mm wire-to-board connectors. Catalog sections are organized by product application, and a new design guide details HDM backplane and midplane connectors. **Circle No. 720**

PC Systems Handbook

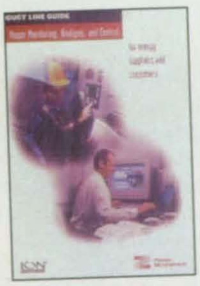
CyberResearch, Branford, CT, has released the 1999-2000 *PC Systems Handbook for Scientists and Engineers.* This 196-page handbook incorporates a buyer's guide, specification charts, tutorials, and a catalog of more than 3,000 products. Listings include industrial PC systems, data acquisition and control equipment, rack-mount PCs, CPU cards, engineering software, instrumentation, and motion control. **Circle No. 721**

Data/Signal Protection



A catalog from Control Concepts, Binghamton, NY, features data/signal protection and surge protection equipment. Included are facility-wide, sine wave surge protection devices; Active Tracking products for protecting critical microprocessor-based equipment; and data/signal products utilizing high-speed, high-energy components in a variety of application-specific voltage levels and configurations. **Circle No. 722**

Power Metering



An 8-page guide from Power Measurement, Saanichton, BC, Canada, describes the ION series of digital power meters and networked software. Selection charts help match products to applications, which include power-quality analysis, revenue billing, energy and demand profiling, cost allocation and load aggregation, alarming and control, and report generation. **Circle No. 725**

Compressed-Air Products

EXAIR Corp., Cincinnati, OH, offers a 72-page technical guide featuring control-panel coolers, quiet air knives, air-saving nozzles, vortex tubes, tool coolers, air-operated conveyors, industrial housekeeping products, and static eliminators. The products are designed for problems associated with industrial cooling, blowoff, cleaning, drying, conveying, and static electricty. **Circle No. 726**

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